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ELEMENTS

OF THE

ART of DYING,

CONTAINING

THE THEORY OF DYING IN GENERAL,

AS FAR AS IT RESPECTS THE PROPERTIES OF COLOURING SUBSTANCES.

Tranſlated from the FRENCH of

M. BERTHOLLET,

MEMBER OF THE ACADEMY OF SCIENCES OF PARIS,

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ADVERTISEMENT.

THE Publiſhers were preparing to lay before the Public, a complete tranſlation of M. Berthollet's whole works, by an able hand: the tranſlation was conſiderably advanced, and ſome progreſs had been made in the printing, when the unexpected appearance of another tranſlation of the ſame book in London, rendered it eligible for them to deſiſt from the undertaking, as the London market was thus pre-occupied.

Senſible, however, that the tranſlation which they were about to publiſh may well bear a compariſon with that which has appeared, and believing that the firſt part, which they printed, may, even ſeparately, prove of conſiderable utility to Students of Chemiſtry, and Practitioners in the Art of Dying; they, upon theſe grounds, preſume to offer it to the Public.

The general properties of colouring ſubſtances, and of thoſe other bodies which are employed to fix colours upon the matters to which they are applied; the action of air and light upon colours; the influence of the nitric and oxigenated muriatic acids in colouring animal ſubſtances; the nature of galls and of aſtringents in general; with the characters of wool, ſilk, and flax as ſubjects for the Art of Dying, are the topics treated of in the part of M. Berthollet's book now publiſhed in an Engliſh dreſs.

ELEMENTS

OF THE ART OF

DYING.

PART FIRST.

OF DYING IN GENERAL.

SECTION FIRST.

OF THE GENERAL PROPERTIES OF COLOURING SUBSTANCES.

CHAP. I.

Of colouring Particles, and their Affinities.

THE phyſical theory of colours is foreign to the object of this work. Before conſidering the characters of colouring ſubſtances, I ſhall only indulge myſelf in a few reflections on the manner in which the particles of bodies abſorb certain rays of light, tranſmit or reflect others, and in that way produce colour.

Newton has demonſtrated, in his Optics, that tranſparent bodies, according to the difference of their thickneſs and denſity, reflect rays of one colour, and tranſmit thoſe of another.

M. Laval * has endeavoured to extend the proofs of the Newtonian theory to all the colours of bodies permanently coloured, and he has collected a great number of experiments, in order to prove that the difference of colour in theſe bodies is exactly in proportion to the denſity of their conſtituent parts.

The application of the beautiful experiments upon colours reflected by thin and tranſparent plates to bodies permanently coloured, is founded upon analogies which did not eſcape the genius of Newton; but we cannot as yet ſay how far it is poſſible to obtain direct proofs of this theory, or to deduce from it any thing certain with regard to particular colours. For,

1*ſt*, The ſame colours are ſucceſſively produced by plates, the thickneſs of which increaſe in a progreſſive order; ſo that we cannot, from the colour produced by a tranſparent plate, whatever its kind may be, determine its preciſe thickneſs.

2*d*, The tenuity of the particles of bodies and their denſity are two elements, which, according to Newton, combine in the tranſparent plates to produce colour; and a plate of water, air, or glaſs, ought to be of different degrees of thickneſs, in order to reflect the ſame colour. But we have no method of determining either the tenuity or the denſity of the particles of bodies. The ſpecific gravity is not ſufficient for this purpoſe, for ſmall particles, with very numerous pores, may give the ſame ſpecific gravity as more extenſive pores, and a ſmaller number of large particles.

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* Recherches expérimentales de changements de couleurs, dans les corps opaques et naturellement colorés.

Thus, when M. Laval aſſerts that the order of colours which metals give to glaſs is in proportion to their ſpecific gravity, he refutes himſelf by the facts he adduces; for he obſerves, that we can make glaſs yellow by means of iron, lead, or ſilver, the ſpecific gravities of which are very different. Mercury combined with a ſmall quantity of oxigen is black, but by combining it with a greater quantity it becomes red. Iron paſſes through almoſt every variety of colour, according to the quantity of oxigen with which it is combined; and the changes of ſpecific gravity that reſult from the different proportions of oxigen are very ſmall, and far leſs conſiderable than the differences which exiſt among the ſpecific gravities of theſe metals.

The ſame author alledges that alkalies give a green tinge to many blue vegetable colours, becauſe they increaſe the denſity of their particles; and that acids change them to a red, becauſe in diſſolving they attenuate them: but alkalies alſo diſſolve the greater part of colouring particles, and render them more miſcible with water than they are in their natural ſtate; they muſt therefore act in a manner analogous to acids: beſides, acids diſſolve blue colouring particles without changing their colour: thus the ſolution of indigo, in the ſulphuric acid, retains its blue colour although it be diluted with a great quantity of water; but according to M. Laval's mode of reaſoning, the denſity of the blue particles ought then to undergo a conſiderable change. In ſhort, many vegetable ſubſtances are changed by means of a very weak acid, or a ſmall quantity of an alkali, from a red colour to a green, without our being able to perceive any of the ſhades which ought to intervene.

The tenuity and denſity of the particles are not the only circumſtances which ought to be conſidered; it is evident, even from the experiments of Newton, that their chemical nature has much influence upon their colours; for we cannot doubt, that a force which exerts a ſtrong action upon the rays in their refraction, will alſo affect their reflection.

In comparing the refractive powers of different ſubſtances, Newton found that inflammable bodies poſſeſſed this power in a much higher degree than ſubſtances not inflammable: he deduced from his obſervations the ſurprizing concluſion that the diamond muſt contain much inflammable matter, that water is an intermediate ſubſtance, between inflammable and uninflammable bodies, and that it is water which affords to vegetables their inflammable principle: truths that, of late only, have been underſtood, and demonſtrated by experiment.

There ſtill remain many intereſting obſervations for thoſe who wiſh to follow the path of the great Newton, and to compare the refractive power of the different gaſes and other ſubſtances, the conſtituent principles of which are at preſent known. Is it hydrogen or carbon which contributes moſt to the refractive power of inflammable ſubſtances? By attending to the experiments which have been made upon the diamond, we would be inclined to conſider it as carbon pure and cryſtalized; but in oil of turpentine, which has a conſiderable refractive power, hydrogen forms the prevailing ingredient.

Many chemical experiments prove that oxigen alſo has a conſiderable affinity with light; it combines with it without ſeparating any of its rays; and reſumes an elaſtic ſtate by this combination, which it always forms when not prevented by a ſtronger affinity. From this it happens, that when we expoſe to the light oxigenated muriatic acid, the oxigen, which is but feebly retained, quits the acid, and aſſumes the elaſtic ſtate by becoming ſaturated with the principle of light: the ſame diſengagement is produced when we expoſe nitric acid to the rays of the ſun, but with greater difficulty, becauſe in this acid the oxigen is more ſtrongly combined. Oxigen is alſo diſengaged in the ſame manner from ſome oxids, or metallic calces.

When a principle enters in a large proportion into any ſubſtance, it generally renders itſelf evident by the properties which it communicates, notwithſtanding the changes they may undergo. Thus oxigen, in combining with metals, communicates to them the property of acting more forcibly upon the rays of light; but the action which they then exert is unequal with regard to rays of different kinds, until the affinity of the oxigen is ſufficiently weakened by heat, ſo that all the rays may combine with it, and render it elaſtic. It is on this account that metallic oxids change their colours by ſlight variations in the proportions of oxigen. In this view the oxid of manganeſe preſents a very remarkable phœnomenon. When it is ſaturated with oxigen, it appears black if its particles are collected together; but if they are extended or diſperſed as in glaſs, into which they are made to enter only in a certain proportion, it gives a red colour, which proves that the apparent black is owing to the red particles being brought into cloſer contact. If we deprive it of a great part of its oxigen, either by carbon or by any other ſubſtance which can ſeparate this principle, the glaſs becomes perfectly tranſparent, and loſes its colour; but we can re-produce the colour by means of nitre, or any other ſubſtance that can reſtore to manganeſe the oxigen which it had loſt. It is in this manner we explain its uſe in the art of making glaſs; it deſtroys the carbonaceous ſubſtances which might alter the purity of the glaſs, and by this means it loſes the property of giving it a colour, provided it be added only in the proper proportion.

In metallic oxids, and in many mineral ſubſtances, all the parts are equally coloured; but it is not ſo with vegetable or animal ſubſtances; in them, colour is generally owing to particles which are mixed or combined with the parts that form theſe ſubſtances; and vegetables ſometimes contain different colouring particles at different periods of their exiſtence, and in different parts.

The colouring molecules of vegetable and animal ſubſtances are almoſt the only ones uſed in dying; but they are often modified by admixtures. In this treatiſe they will be diſtinguiſhed by the name of Colouring particles.

Theſe colouring particles do not exhibit, in their compoſition, the ſimplicity of mineral ſubſtances, and their colours are not affected in the ſame manner by oxigen. We ſhall examine, in one of the following chapters, the manner in which this principle acts upon and decompoſes them.

Some chemiſts have conſidered iron as the cauſe of all vegetable and animal colours; and M. Becker has employed, to ſupport this opinion, arguments taken from the property that a metal, ſo generally diffuſed, has, of aſſuming a great variety of colours, in the ſtate of an oxid, in ſolutions, and in vitrifications *.

Iron indeed appears to be contained in all vegetable and animal ſubſtances, but in an extremely ſmall quantity. The oak, which is one of thoſe vegetable ſubſtances that ought to give the greateſt reſiduum, affords by combuſtion only $\frac{1}{200}$ of its weight in aſhes, and theſe aſhes do not contain $\frac{1}{200}$ of iron. Can we explain, by ſo ſmall a quantity, the rich and ſhining colours with which vegetables are enamelled? Is there any true relation between the readineſs with which ſome of theſe colours are changed, by acids, by alkalies, and by air, and that conſtant ſucceſſion of colours which iron aſſumes, according to its ſtate of oxidation?

I know that the opinion I combat may be ſupported by the authority of Bergman, who has endeavoured to prove that indigo owes its colour to the iron which it contains †; but I ſhall only remark, that it is eaſy to prove that this great chemiſt has been deceived with regard to this point. By means of the pruſſiate of alkali, he obtained from the aſhes of an ounce of indigo from 30 to 32 grains of Pruſſian blue, and he calculates the iron it contained at 18 or

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* Specimen ſiſtens experimenta circa mutationem colorum quorumdam vegetabilium á corporibus ſalibus, cum corollariis; auctore J. F. Adolpho Becker, 1779.

† Analyſe chymique de l'indigo. Mem. des Sav. étr. tom. IX.

20 grains; but, in ſome other places, he proves that the iron contained in any ſubſtance does not form more than a fifth part of the Pruſſian blue that we obtain from its ſolution, and he has every where elſe employed this calculation, which is very exact. He ought then to have calculated the iron that he obtained from an ounce of indigo at no more than ſix grains; but in the experiments which follow, he proves that the greateſt part of this iron may be diſſolved by the muriatic acid, without any alteration of the colouring particles, ſo that the greateſt part of the metal does not enter into their compoſition. It follows clearly from this, that the colouring particles of this ſubſtance contain a quantity of iron ſo ſmall, as to affect its colour only in a very inconſiderable degree. It appears to me alſo, that it is upon very weak grounds that phyſiologiſts have concluded, from the experiments of Menghini, that iron is the immediate cauſe of the colour of the blood.

The methods of chemical analyſis which we poſſeſs, do not enable us to determine with ſufficient preciſion the compoſition of the colouring particles, in order to know from what principles they derive their properties, and it can be ſhown that a very different compoſition may give riſe to a colour of the ſame kind. The particles of indigo differ much from thoſe which give a blue colour to many flowers. We have a great number of yellow ſubſtances, differing widely in their properties, and yet affording colours nearly ſimilar in appearance.

There are ſome colours which are ſimple; there are others which are owing to a mixture of theſe colours, and which are conſequently compound. Newton has given a general rule for producing any colour whatever, by means of the other priſmatic colours. Le Blon has ſhown, that we can procure every colour which the art of painting requires, by a mixture of red, of blue, and of yellow *. Dufay found, that we can obtain the ſame effect in dying, and on this account he concludes that there are only three primitive colours in nature, from which all the reſt are derived. This opinion has been adopted by many philoſophers, but it is eaſy to prove that it is without foundation.

There is this difference between ſimple colours and colours formed by the union of different rays, that the former ſeen through the priſm retain their ſimplicity, while the latter are decompoſed. But the green produced by the rays of this colour ſuffers no decompoſition by the priſm; it poſſeſſes then the character of a ſimple and primitive colour, but that which is compound is ſeparated into yellow and blue. Although the green that we obtain in dying is owing to a mixture of yellow and blue, yet we ought not to conſider all greens as a combination of theſe two kinds of colouring particles; thus the green oxid of copper cannot owe its colour to particles of a different nature: and the green colour of plants is undoubtedly produced by a homogeneous ſubſtance, as well as the greater part of the ſhades which exiſt in nature.

I ſay, that the greater part of vegetable colours appear to me to be owing to a homogeneous ſubſtance, but this ſubſtance may produce green, for example, by

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* L'Harmonie du coloris dans la peinture réduite en pratique.

by the reflection of a green ray, or by that of yellow and blue rays; and there are ſeveral colours, which are neceſſarily produced by the reflection of different kinds of rays. If the green colour of plants be owing to two ſubſtances, one of which is yellow, and the other blue; it appears ſurpriſing that we cannot ſeparate them, or at leaſt change their proportions by ſome ſolvent; however, there are ſubſtances which contain colouring particles of different kinds, ſuch as madder, as we ſhall afterwards ſee in the ſecond part.

The green, which I take as an example of a real compound colour produced by dying, makes it evident, that the colouring particles cover only a part of the ſurface of the ſtuff, although it appears of a full and uniform colour; for, after the ſtuff has been dyed blue, the yellow parts are fixed on it, and produce the green; and what proves that it is upon the parts of the ſtuff, and not upon thoſe of the indigo that they are chiefly fixed, is, that although we begin the dying with a yellow, if we employ a yellow that is not very fixed, it may be deſtroyed by the air, and eſpecially by chemical agents, while the blue remains almoſt without any alteration.

From this, it appears that it is only neceſſary that rays of different colours ſhould be brought together, in order to give us an idea of a ſimple colour. Indeed we can produce a uniform colour by the careful mixture of wool of different colours, and in painting we obtain ſimple ſhades by the mixture of different ingredients which do not combine together.

The colouring particles form different combinations, and they are applied to wool, to ſilk, to thread, and to cotton, either alone, or previouſly combined with other ſubſtances. The art of dying conſiſts in employing the affinities of the colouring particles in order to extract, diſſolve, and afterwards apply, and fix them on the ſubſtances to be dyed.

Some have attempted to diſtinguiſh colouring particles into extractive and reſinous; but this diviſion can only give imperfect and falſe ideas of their properties; for there are colouring particles, which, not being ſoluble in water, might be conſidered as reſinous, were they not equally inſoluble in alcohol. Such are the red colouring part of the carthamus, (baſtard ſaffron), which is diſſolved only by means of an alkali, and indigo; which is neither ſoluble in water nor in alcohol, but which is readily diſſolved in the ſulphuric acid, and by means of certain proceſſes is rendered ſoluble in alkalies.

The colouring particles which are diſſolved in water cannot be compared to the mucilaginous and extractive parts of vegetables; ſince the property which theſe ſubſtances poſſeſs, of diſſolving in water, affords no idea of the properties which are eſſential to them; ſuch as their relations with the chemical agents which are uſed in dying, with air, with light, and with vegetable and animal ſubſtances.

There is another error, hurtful to the progreſs of true theory; that of attempting to explain the properties of colouring ſubſtances by the mucilaginous, reſinous, earthy, ſaline, and oily particles, which are ſuppoſed to enter into their compoſition in the manner that Mr Poerner has chiefly attempted. An error ſimilar to the abſurd explanations that have often been given of the action of medicines. (Vid. Mater. Med. Cartheuſ.)

Thus we ſee, that in explaining the cauſe of colours, and the nature of colouring particles, authors have fallen into two miſtakes; one, that of endeavouring to explain the action which the particles of colouring ſubſtances exert upon the rays of light, by their denſity and thickneſs, without having any method to determine, or without any regard to the affinity depending on their chemical compoſition; the other, that of comparing on ſome feeble analogies, the colouring particles with mucilages and reſins, and endeavouring to explain their properties from the parts which are ſuppoſed to enter into their compoſition; while their colouring properties ought rather to be determined by direct experiment, than explained by any imaginary compoſition. It was little conſonant to true theory, which is only the reſult of obſervation, to attribute to laws purely mechanical the adheſion of colouring particles to the ſubſtances which we dye; the action of *mordants*, and the difference of the colours of the true and falſe dye. Hellot, to whom we are indebted for the beſt work extant on dying, has deceived himſelf completely on this ſubject; his theoretical ideas have often influenced his obſervations and the principles which he has eſtabliſhed, as any one may be convinced of by reading his work. We may judge of his theory by the following paſſage: "I believe we may lay it down "as a general principle in the art of which I treat, that "the whole inviſible mechaniſm of dying conſiſts in "dilating the pores of the body to be dyed, in depoſiting in them the particles of a foreign ſubſtance, and retaining them there by a kind of cement, which neither water nor rain, nor the rays of the ſun can alter. In chooſing colouring particles of ſuch tenuity, that they may be retained, properly wedged in the pores of the ſubſtance opened by the heat of boiling water, then contracted by cold, and afterwards coated with a kind of varniſh, that the ſalts employed in preparing the ſtuffs had left in the pores; from this it follows, that the pores of the fibres of wool, which we have formed, or mean to form into ſtuffs, ought to be cleanſed, enlarged, varniſhed, and then contracted; ſo that the colouring particle may be retained like a diamond in the beaſel of a ring *."

We have reaſon to be ſurprized, that Macquer, who was one of the firſt who entertained juſt notions with regard to chemical affinities, ſhould have been ſeduced by the ideas of Hellot †. "It would be eaſy, in this place," ſays he, "to explain the manner in which *mordants* act in dying, and to develope the cauſe of the true and falſe dye; but theſe objects have been treated ſo well by M. Hellot, that I need only refer the reader to his work."

However, M. Dufay had already perceived that the colouring particles were diſpoſed according to their different natures to form a ſtronger or weaker adheſion to the filaments which receive them: he obſerves, very properly, that, without this diſpoſition, the ſtuffs ought only to aſſume the colour of the dying vat, and to divide equally the colouring particles with it; whereas the liquor of the vat becomes ſometimes as clear as water, and yields all the colouring particles to the ſtuff; which ſeems (ſays he) to prove that the ingredients adhere leſs ſtrongly to the water than to the particles of the wool. He adds, that we can account in the ſame manner for ſeveral other appearances; but that ſuch an explanation is ſtill unſatisfactory, and that he would abandon it without reluctance, if a more probable one were propoſed.

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* L'Art de la teinture des laines. p. 42.

† L'Art de la teinture en ſoie, avant-propos, p. 8.

Bergman ſeems to have been the firſt who referred the phenomena of dying completely to chemical principles *: having dyed wool and ſilk in a ſolution of indigo in the ſulphuric acid much diluted with water, he explains, in the following manner, the effects that he obſerved in this operation; he attributes them to the precipitation occaſioned by the greater affinity ſubſiſting between the wool and ſilk, and the blue particles, than between the ſame particles and the acidulated water: he remarks, that this affinity of the wool is ſufficiently ſtrong to deprive the liquor entirely of its colouring particles, but that the weaker affinity of the ſilk can only diminiſh the proportion of theſe particles in the vat; and he has made it appear, that upon theſe different affinities depend both the durability of the colour and the intenſity which it aſſumes.

This is the proper method of conſidering the phenomena

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* Analyſe de l'indigo, Mem. des Sav. etre. T. IX. et dans les notes ſur le traité de Scheffer.

mena of dying; they are true chemical phenomena, which ought to be analyſed like all thoſe that depend upon the action which bodies exert in conſequence of their peculiar nature.

Colouring particles have chemical properties, which diſtinguiſh them from all other ſubſtances; they have affinities which are peculiar to themſelves; in conſequence of theſe affinities, they combine with acids, alkalies, metallic oxids, with ſome earths, and principally with alumine: they frequently precipitate the oxids and alumine from the acids which hold them in ſolution; in other circumſtances, they combine with ſalts, and form with them ſupra-compounds which unite to wool, to ſilk, to cotton, and to thread. In general, they form with theſe laſt ſubſtances, by means of alumine, or of a metallic oxid, a much more intimate combination than without this admixture.

The difference of the affinity of the colouring particles with wool, ſilk, and cotton, is ſometimes ſuch, that they refuſe to combine with one of theſe ſubſtances, while they combine very readily with another; thus, cotton is not affected in the vat which dyes wool of a ſcarlet colour. Dufay cauſed a piece of ſtuff to be made, of which the warp was wool and the woof cotton: in order to be certain that the wool and cotton received exactly the ſame preparation, he made the piece paſs through the hands of the fuller; but the wool took on the colour of ſcarlet, and the cotton remained white. It is this difference of affinity that obliges us to vary our preparations and proceſſes, according to the nature of the ſubſtance that we wiſh to dye of any particular colour.

Theſe conſiderations ought to fix the plan we are to follow in explaining the art of dying.

It is undoubtedly proper to attempt to aſcertain what the conſtituent parts of colouring particles are; for although this analyſis alone cannot as yet lead us to extenſive concluſions, we ſhall ſee, however, that we are already able to determine in what certain changes produced in theſe particles by differ ent agents conſiſt.

It is of the utmoſt conſequence to determine the relations of the colouring ſubſtance, *1ſt*, With the ſubſtances that may be employed as ſolvents; *2dly*, With thoſe which can by their combination modify their colour, increaſe their brightneſs, and aſſiſt in fixing their union with the ſubſtances dyed; *3dly*, With the different agents which can alter their colour, and principally with air and light.

It muſt not be forgotten, that the qualities of free colouring particles are changed when they enter into combination with any ſubſtance; but if this combination unites with the ſtuff, it undergoes itſelf new changes. Thus the properties of the colouring parts of cochineal are modified by its combination with the oxid of tin, and thoſe of the ſubſtance which reſult from this combination are alſo modified in combining with wool or with ſilk; ſo that the knowledge we acquire by examining ſubſtances by themſelves, can only inform us as to the preparations they may be made to undergo; that which we acquire with regard to the combinations with ſubſtances employed to fix or to increaſe the beauty of colours, may direct as to thoſe proceſſes in dying that ought to be adopted or that may be attempted; but it is only direct experiment made with the different ſubſtances to be dyed, that can verify our conjectures and bring proceſſes into uſe.

In this ſeries of obſervations, we are frequently able to explain the circumſtances of an operation which we owe entirely to a blind practice, improved by the trials of many ages; we ſeparate from it every thing ſuperfluous; we ſimplify what is complicated; and we employ analogy in transferring to one proceſs what has been found uſeful in another. But there is ſtill a great number of facts which we cannot explain, and which elude all theory: we muſt then content ourſelves with detailing the proceſſes of the art; not attempting idle explanations, but waiting till experience throw greater light upon the ſubject.

It follows from the preceding obſervations, that the changes produced by acids and alkalies in many vegetable colours, and of which chemiſts make great uſe in aſcertaining the nature of different ſubſtances, are owing to the combination which is formed between the colouring particles and the acids or alkalies. We may compare the compounds that are formed to neutral ſalts, which poſſeſs properties different from thoſe of their component parts, but in which one of the component parts may become ſuperabundant, ſo that the properties ſhall prevail. We obſerve this ſtate of combination between the colouring particles of cochineal and the acidulated tartar of potaſh, or cream of tartar; by evaporating ſlowly a ſolution of this ſalt in a decoction of cochineal, cryſtals are formed which preſerve a beautiful ruby colour, much deeper and more lively than that of the liquor in which they are formed.

There are acids, particularly the nitric acid, which, after being united with colouring particles, alter the colour they at firſt produced, render it yellow, and deſtroy it. They act then by means of one of their component parts, the oxigen, in a manner that will be explained when we come to treat of the action of air, and of the oxyginated muriatic acid upon colouring particles.

The blue are not the only colours that become red by the action of acids, and green by that of alkalies; the greater part of red colours, that of the roſe for example, are heightened by acids, and become green by alkalies; and ſome green colours, ſuch as the green decoction of Burdock, according to the teſtimony of M. Noſe, and the green juice of the berries of Buckthorn, according to the obſervation of M. Becker, become alſo red by acids.

This property, common to the moſt ordinary vegetable colours, ſeems to prove, that there is a ſtrong analogy between the greater part of their colouring particles: and it was not without foundation that Linnæus imagined that the red colour in vegetables was owing to an acid, and was a proof of its exiſtence in them *; but there are many vegetables which contain

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* The colour of ſome flowers appears to be naturally modified by a very weak acid without being decidedly red: ſuch is the flower of the violet, the juice of which becomes blue when it is allowed to remain for a time in a veſſel of tin; probably becauſe the acid it contained combines with the oxidated part which is found on the ſurface

tain an acid fully elaborated, without having any red colour.

Colouring particles have their affinities with acids, alkalies, earths, and metallic oxids, which partly conſtitute their chemical properties, and according to which their colours undergo greater or leſs changes.

Theſe particles form then with the ſtuff* upon which they are fixed, a combination which retains only a part of their primitive properties, in uniting with allum, metallic oxids, and ſome other ſubſtances. They are alſo modified; but the properties of theſe laſt combinations are ſtill the ſame when united with the ſtuff. All theſe changes are ſimilar to what we obſerve in other chemical combinations. They will afterwards be examined more in detail.

CHAP. II.

Of Mordants.

WE give the name of *Mordant* to ſubſtances employed in facilitating or modifying the combination of the colouring particles with the ſtuffs which are to be dyed.

Mordants

ſurface of the veſſel; ſuch alſo is the flower of the mallow, which becomes blue by ſimple drying. Theſe recover their primitive hue from the addition of a very ſmall quantity of acid. Obſerv. Phyſico. chym. ſur les couleurs. Journ. de Phyſ. tom. VIII.

[*] Throughout this work, the word *ſtuff* means any thing that is the ſubject of dying, whatever may be its nature or form.

Mordants deſerve the greateſt attention; it is by their means we vary colours, that we increaſe their brightneſs, that we fix and render them more durable.

The analyſis of the action of *mordants* is what in a peculiar manner converts dying into a chemical art, and a more extenſive knowledge of their effects muſt contribute much to the perfection of this art.

I ſhall deſcribe, in the third ſection, the eſſential properties of the chemical agents which are chiefly employed as *mordants*: I ſhall aſcertain, in treating of each colouring ſubſtance, the effects they produce upon it. In this chapter I ſhall examine in what the action of the principal *mordants* conſiſts, and endeavour to determine how their affinities intervene between the colouring particles and the ſtuff, and how they influence the qualities of the colours.

A *mordant* is not always a ſimple agent; for among the ſubſtances of which it is compoſed, there are ſometimes formed new combinations, ſo that the ſubſtances employed do not act directly, but the combinations which reſult from their mixture.

Sometimes we mix the *mordant* with the colouring particles, at other times we impregnate the ſtuff with it; in other circumſtances we unite theſe two methods, or we may dye ſucceſſively with liquors containing different ſubſtances, the laſt of which can act only upon the particles with which the ſtuff is already impregnated.

As the art of printing callicoes exhibits many proceſſes, in which it is eaſy to proſecute the effects of *mordants*, I ſhall take a few examples from it, which will render more intelligible the theory afterwards to be explained. The *mordant* applied to cloths that are to receive different degrees of red, is prepared by diſſolving in 8lbs. of hot water 3lbs. of alum, and 1 lb. of acetite of lead, or ſugar of lead; and we add to it 2 oz. of potaſh, and afterwards 2 oz. of chalk in powder *.

The alum is decompoſed by the acetite of lead, becauſe the oxid of lead combines with the ſulphuric acid, and forms an inſoluble ſalt which is precipitated; the baſe of the alum or alumine combines at the ſame time with the acetous acid, by which an acetite of alumine is formed; the chalk and the potaſh ſerve to ſaturate the exceſs of the acid.

One great advantage that reſults from the formation of the acetite of the alumine is, that the alumine is retained in it by an affinity much weaker than in alum, ſo that it parts more readily with its ſolvent, to combine with the ſtuff and the colouring particles.

A ſecond advantage is, that the acid liquor from which the alumine is ſeparated acts leſs powerfully upon the colour when it is the acetous acid, than when it is a ſtronger acid, ſuch as the ſulphuric.

Laſtly, the acetite of alumine not poſſeſſing the property of cryſtallizing, the *mordant*, that is thickened by means of ſtarch or gum, before applying it to the mould on which the pattern is engraved, does not become rough and unequal, as it might if it contained alum that would cryſtallize.

Let us follow the operation which is performed upon a piece of cloth when it is impregnated by the *mordant*

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* We ſhall be more particular on this head in treating of *madder*.

dant in the manner determined by the pattern: it is put into a madder vat; the whole piece is coloured, but the colour is deeper upon the parts that have received the *mordant*. There the colouring particles are combined with the alumine, and with the cotton; ſo that it is this triple combination that is formed, and the acetous acid being diſengaged from its baſe, is left ſuſpended in the vat.

The colouring particles combined with the alumine and the ſtuff are far leſs eaſily affected by external agents than when they are either iſolated or united to the ſtuff without any intermediate ſubſtance; and it is upon this property that the operations are founded to which the cloth is afterwards ſubjected; after having paſſed through the madder vat, it is boiled with bran, and expoſed upon the bleaching field; and theſe operations are alternately repeated, till the baſe becomes white. The colouring particles, which are not united with the alumine, are altered in their compoſition, diſſolved, and ſeparated; while thoſe which are combined, reſiſt, and are preſerved without alteration; ſo that the ſtamp alone remains coloured.

This deſtruction of the colouring particles, by expoſure on the field, and by boiling with bran, ſeems to be produced, and ought to be explained in the ſame manner with that of the colouring particles of thread; the only difference in the proceſs is, that we employ bran inſtead of alkalies, becauſe the latter would diſſolve a part of the colouring ſubſtance which is fixed by the alumine, and would alter its colour; whereas the bran, having a much leſs affinity for this ſubſtance, acts only upon the colouring particles that have been diſpoſed by the influence of the air, to diſſolve more readily.

If, inſtead of the *mordant* we ſpeak of, we employ a ſolution of iron, the ſame phenomena take place; the colouring particles decompoſe the ſolution of iron, and form a triple combination with the ſtuff. But, inſtead of a red colour, we obtain from the madder different ſhades of brown, from the lighteſt even to a black, and by uniting the *mordant* of the alum to that of the iron, we obtain mixt colours, which are partly red, and partly black; ſuch are the *mordoré* or golden, and the *puce* or flea colour.

In ſhort, we procure other colours, by uſing woad inſtead of madder; and by means of theſe two colouring ſubſtances, indigo blue, and the two *mordants* of which we have been ſpeaking, we obtain the greater part of the varied ſhades that we obſerve on printed cloths.

The ſubſtances which enter into the compoſition of a *mordant* cannot ſometimes be decompoſed by the force of their own affinities; but the affinity of the ſtuff for one of the conſtituent parts occaſions a decompoſition, and new combinations, and ſometimes this effect cannot be produced, or at leaſt compleated, without the aid of the affinity of the colouring particles. This appears to be the caſe with the mixture of alum and tartar, which is the *mordant* chiefly employed in the dying of wool.

I diſſolved equal weights of alum and tartar; this laſt ſalt acquired by the mixture a greater degree of ſolubility than natural; but by evaporation, and by a ſecond cryſtallization, the alum and the tartar ſeparated,

ted, ſo that they had not been decompoſed. I boiled half an ounce of alum with an ounce of wool for an hour; a precipitate was formed, which I waſhed carefully: this precipitate was chiefly compoſed of ſmall filaments of wool encruſted with earth. I expoſed it to the action of the ſulphuric acid, dried it by evaporation, and diſſolved the reſiduum, from which I obtained cryſtals of alum; it depoſited carbonaceous particles. I evaporated the liquor which had been boiled with the wool; I obtained from it a few grains of alum; the remainder did not cryſtalliſe. I rediſſolved it, and precipitated the alumine by an alkali; the precipitate was of a ſlate colour, it became black upon burning charcoal, and gave out alkaline vapours.

We ſee from this experiment, that the wool decompoſed the alum, that a part of the alumine combined with the filaments which were the moſt iſolated and the moſt weakly kept together by the force of aggregation; that an animal matter had been diſſolved and precipitated by the alkali from the triple combination which was formed.

I made the ſame trial with half an ounce of alum and two drachms of tartar; in this there was no precipitate formed. I obtained, by evaporation, a ſmall part of the tartar and ſome cryſtals of alum of a very irregular figure; the remainder did not cryſtallize. I diluted it with water, and precipitated it with potaſh, and I obtained, by evaporation, a ſalt that burned like tartar.

The wool which had been boiled with the alum, became rough to the touch, but the other preſerved its ſoftneſs; the former aſſumed with the madder a duller colour,

lour, though leſs deep; and the latter a colour more full and lively.

I cannot give in detail the explanation of what took place in theſe experiments, but we ſee,

1ſt, That the wool had begun to decompoſe the alum, that it combined with a part of the alumine, and that the part of the alum which retained its alumine had diſſolved a ſmall quantity of an animal ſubſtance.

2d, That the tartar and the alum, which are not mutually decompoſed when they act only by their own affinities, may act upon one another when their affinities are altered by thoſe of the wool.

3d, The tartar appears to be particularly uſeful in moderating the too great action of the alum upon the wool, which is ſomewhat injured by it; thus no uſe is made of tartar for the aluming of ſilk and thread, which have leſs action upon the alum than wool.

As the decompoſition of the alum by the tartar and the wool is only produced by affinities, which loſe their equilibrium with difficulty; and as, of conſequence, it can only be performed ſlowly, we may perceive why it is advantageous to keep for ſome days in a moiſt place, the ſtuff impregnated with alum and tartar, as is commonly adviſed.

The laſt reſult of the aluming, in whatever manner it may have been performed, and whatever the chemical changes may be which have been produced, conſiſts in the combination of the alum with the ſtuff. This combination is perhaps at firſt imperfect, having parted with only a portion of the acids; but it is completed,

completed by boiling the wool with madder, juſt as we have ſeen it performed on printed cloths.

An acid and an alkali may, at the ſame time, be united with the ſtuff, the colouring ſubſtance, and the alumine; for there are colours which are altered by an acid, and reſtored by an alkali, or by a calcareous earth, which deprives them of their acid, or produces an effect contrary to it. But this ſupracompoſition takes place only with colours which may be conſidered as fixed, and which are unalterable by acids or alkalies that are not ſufficiently ſtrong to deſtroy their compoſition.

The affinity of alumine for animal ſubſtances is not indicated by doubtful phenomena only, nor invented to ſerve merely for explanation; it is demonſtrated by direct experiments. I have formed this combination by mixing an alkali, ſaturated with an animal ſubſtance, with a ſolution of alum; a double exchange takes place; the alkali unites with the acid of the alum, while the alumine is precipitated in combination with the animal ſubſtance *.

I have proved, by another experiment, the affinity of the alumine for animal ſubſtances. After having mixed a ſolution of ſtrong glue and a ſolution of alum, I precipitated the alumine with an alkali; it carried along with it the ſtrong glue with which it had been combined: this combination has the appearance of a ſemitranſparent jelly, and is dried with difficulty †.

We have ſeen alſo in the preceding experiments, that the alkali had precipitated the alumine combined with

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* Mém. de l'acad. 1784.

† Ann. de chym. tome IV. p. 155.

with the animal ſubſtance, from the uncryſtalliſable reſiduum of the alum which had been boiled with the wool.

The affinity of alumine for the greater part of colouring ſubſtances may alſo be demonſtrated by direct experiment. If we mix a ſolution of a colouring ſubſtance with a ſolution of alum, a precipitate is ſometimes formed; but if we add to the liquor an alkali which decompoſes the alum, and ſeparates the alumine from it, then the colouring particles are precipitated in combination with the alumine, and the liquor remains clear. It is to this combination that we give the name of Lac: we muſt not, in making this experiment, uſe too great a quantity of alkali, becauſe the alkali has the property of re-diſſolving the greater part of lacs.

No direct experiment has hitherto proved the affinity of alumine for any vegetable ſubſtances, except the colouring particles; it appears to be much weaker than that which it has for animal ſubſtances: it is for this reaſon that the acetite of alumine, as has formerly been obſerved, is a better *mordant* for cotton and thread than alum, and on this depend the different methods employed to increaſe the ſolidity of the colouring particles of the madder in the dying of theſe ſubſtances.

The metallic oxids have ſuch an affinity with ſome colouring particles, that in order to precipitate themſelves in combination with them, they quit the acids by which they are held in ſolution.

On the other hand, all the metallic oxids have the property of combining with animal ſubſtances; and I have formed theſe different combinations by mixing an alkali, ſaturated with animal matter, with metallic ſolutions *. It need not then appear ſurpriſing, that metallic oxids may ſerve to promote the union between the colouring particles and animal ſubſtances; but, beſides the affinity of oxids for the colouring particles and animal ſubſtances, there are in their acid ſolutions properties which render them more or leſs fit to ſerve as *mordants:* thus oxids that part readily with their acids, ſuch as the oxid of tin, may combine with animal ſubſtances without the aid of colouring particles; it is enough to impregnate the wool or the ſilk with the ſolution of tin, although we afterwards waſh them carefully, which does not happen with ſome other metallic ſolutions.

Some metallic ſubſtances bring into their combinations only a white and colourleſs baſe, there are others that modify, by the union of their colours, that which is peculiar to the colouring particles; but in many metallic oxids the colour varies according to the proportion of the oxigen that is fixed in them, and this proportion may readily undergo ſome changes. On theſe circumſtances, which will be examined in the ſequel of this ſection, depend principally their properties in dying.

The affinity of metallic oxids for ſubſtances of a vegetable nature, appears to be much weaker than that which they have for animal ſubſtances, and it is even unknown whether they can form true combinations with them. Thus, metallic ſolutions are not very fit to ſerve as *mordants* for the colours of cotton and thread. It is neceſſary, however, to except iron, the oxid of which combines ſtrongly with vegetable ſubſtances, as the ſpots of mildew, which are produced by a true combination of this oxid, demonſtrate.

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* Mém. de l'acad. 1784.

When the colouring particles have precipitated a metallic oxid from its ſolvent, the ſupernatant liquor retains the acid which has been ſet at liberty; it has generally the power of diſſolving a portion of the combination of the colouring ſubſtance with the metallic oxid, ſo that the liquor remains coloured; but ſometimes all the colouring particles are precipitated when the proportions are very exact; this precipitation is facilitated and rendered more complete by the preſence of the ſtuff, which acts alſo by the tendency which it has to unite with the combination of metallic oxids and colouring particles.

The free metallic oxids, when boiled with ſeveral colouring ſubſtances, have alſo a very conſiderable action upon them by which their colour is changed. The oxid of tin in a particular manner increaſes the brightneſs and ſolidity of ſome colours.

We may compare the combinations of oxids with colouring ſubſtances to ſeveral other chemical combinations, that are inſoluble when the principles which form them exiſt in the proper proportions; but which may be combined with an exceſs of one of theſe principles, and in that way be rendered ſoluble. Thus, a metallic oxid combined with an exceſs of colouring matter forms a liquor the colour of which is modified by the oxid; whereas, when the colouring particles are not in exceſs, the combination is inſoluble or nearly ly ſo*. Theſe effects are very evident in the combination of iron with the aſtringent principle.

Neutral ſalts, ſuch as nitre, and eſpecially muriate of ſoda, ſerve as *mordants*, and to modify colours; it is difficult to determine in what manner they act. I have found that the muriate of ſoda exiſts in ſubſtance in the precipitates that it forms with ſome colouring ſubſtances; and that theſe precipitates retain a tolerable degree of ſolubility. It would appear that a ſmall part of the ſalt is fixed with the colouring particles and the ſtuff.

Salts with a calcareous baſe alſo modify colours; but as theſe changes are almoſt ſimilar to thoſe that a ſmall quantity of quick lime would occaſion, it is probable that they are decompoſed, and that a ſmall portion of the lime enters into combination with the colouring particles of the ſtuff.

If we attend to what has already been ſaid, the combinations which are formed by the action of the different re-agents that are employed in the analyſis of colouring ſubſtances will be eaſily underſtood; but it muſt not be forgotten, that *mordants* and colouring particles exert a mutual action, by which their properties may be altered.

We have already perceived, that by varying the *mordants* we can multiply prodigiouſly the ſhades that are obtained from a colouring ſubſtance; it is even ſufficient to vary the method of applying them. Thus different reſults are obtained by impregnating the ſtuff with a *mordant*,

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* Obſervations ſur la combinaiſon des oxides metalliques avec les parties aſtringentes & les parties colorantes des vegetaux. (Ann. de chym. tom. 1.)

mordant, or by mixing the *mordant* in the dying vat, by making uſe of heat, or by employing deſiccation; for we have three reciprocal affinities, that of the colouring particles, that of the ſtuff, and that of the principles of the *mordant*; and many circumſtances can produce variations in the reſult of each of theſe affinities, which merit ſome explanations.

Deſiccation favours the combination of the ſubſtances which have an affinity with the ſtuff, and the decompoſitions that may reſult from this combination; becauſe the water which holds theſe ſubſtances in ſolution oppoſes, by its affinity, the action of the ſtuff; but the deſiccation ought to be ſlow, that the ſubſtances may not ſeparate before their reciprocal affinities have produced their effect. From this it may be underſtood in what manner the repeated deſiccations act which are employed in ſome proceſſes.

The greater or leſs diſpoſition that the ſtuff has to combine with the colouring particles produces ſometimes conſiderable changes in the manner in which the *mordant* ought to be employed: thus, when this diſpoſition is great, we can mix the *mordant* with the colouring ſubſtance: the combination which is formed unites inſtantly with the ſtuff; but if it acts only by a weak affinity, the combination which is formed between the colouring particles and the *mordant* may be ſeparated and precipitated before it is fixed upon the ſtuff. In order to prevent this inconvenience, it is neceſſary to begin by fixing upon the ſtuff the ſubſtance which is to ſerve as the intermedium between it and the colouring particles. From theſe obſervations, I ſhall deduce the explanation of the differences which exiſt between the proceſſes employed for dying black, and for dying wool or ſilk with cochineal.

Independent of the conſiderations which follow, it is neceſſary then, in order to judge of the effects of *mordants*, and of the moſt advantageous manner of applying them, to attend, 1*ſt*, To the combinations which ought to be formed, either by the action of the ſubſtances which compoſe them, or by that of the colouring particles, and of the ſtuff: 2*d*, To the circumſtances which may concur in forming theſe combinations, more or leſs readily, and more or leſs completely: 3*d*, To the action the liquor may have in which the ſtuff is immerſed, either upon its colour or texture; and in order to foreſee what this action may be, it is neceſſary to know the proportions of the ingredients which enter into the compoſition of the *mordant*, and which ought to be ſet at liberty in the liquor.

Mordants are not taken from the claſs of ſalts alone: vegetable and animal ſubſtances ſerve mutually as *mordants* in certain circumſtances; thus, in the proceſs for dying the red of Andrinople, (which will be deſcribed in the ſecond part), the cotton ought to be impregnated, or rather combined with an animal ſubſtance: thus, the aſtringent principle is frequently employed as an intermedium between the colouring particles and the ſtuff. Nobody has hitherto varied *mordants*, and the manner of applying them ſo much, as M. Poerner; and his works, in this reſpect, may be of great uſe, particularly the one which has been lately tranſlated.

CHAP. III.

Of the action of different Subſtances, and particularly of Air and Light, upon Colours.

WE have hitherto conſidered the colouring particles only as ſubſtances that can form different combinations, in conſequence of which their properties are changed; but they may be altered in their compoſition, either by external agents, or by the ſubſtances themſelves with which they are combined. It is proper to begin, by examining the changes produced by external agents, becauſe they are the moſt eaſily aſcertained.

The property of reſiſting vegetable acids, alkalies, ſoap, and particularly the action of air and of light, conſtitutes the durability of a colour; but this property is differently eſtimated, according to the nature of the colour, and according to the kind of the ſtuff; for the ſame durability is not required in ſome colours of ſilk, as in thoſe of wool.

There is nothing obſcure in the action of water, acids, alkalies, or ſoap; it is a ſolution produced by means of theſe agents; and ſometimes it appears that a ſmall portion of the acid or alkali unites with the combination which forms the colour, ſince the colour is not deſtroyed, but changed only; and we can reſtore it by ſaturating the acid, by means of chalk or ammoniac.

It is otherwiſe with the action of air and of light: till of late, it was not known in what their action conſiſted;

but at preſent much greater progreſs has been made in this ſubject; and we perceive that experiments only are wanting to enable us to arrive at a very accurate knowledge of it.

Scheele had obſerved, that the oxigenated muriatic acid rendered vegetable colours yellow; and he attributed this effect to its property of abſtracting the phlogiſton which entered into their compoſition.

I have ſhown * that the properties of the oxigenated muriatic acid are owing to the oxigen that is taken from it by the ſubſtances on which it acts: that it generally changes the colouring particles to a yellow; but that, by a continued action, it deſtroys their colour, without aſcertaining in what that action conſiſts.

M. Fourcroy afterwards made many obſervations which throw much light on the changes that oxigen produces on colouring particles; chiefly when their aqueous ſolution is expoſed to the air, or when boiled: he has obſerved, that by the action of air vegetable decoctions form pellicles which loſe their ſolubility, and gradually change their colour: he has attended to the gradations of thoſe that are obtained in that way; and he has concluded from his obſervations, that oxigen enters into the compoſition of the colouring particles; that when it combines with them their ſhades are changed; that the more they receive of it, the more fixed their colour becomes; and that the method of obtaining unalterable colours for painting, is to chuſe thoſe that have

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* Mem. de l'Acad. 1785.

have been ſubmitted to the action of the oxigenated muriatic acid *.

I have been particularly engaged in endeavouring to aſcertain the action of air upon colours of different natures, by analyſing that of the oxigenated muriatic acid † in a memoir, of which I ſhall give a ſhort abſtract.

It is neceſſary to diſtinguiſh, with regard to the effects of air, the colours of the metallic oxids from thoſe of the colouring particles. I have proved, that the modifications of the firſt are entirely owing to their different proportions of oxigen, as I have ſaid in the firſt chapter of this ſection: but I have been led by my obſervations to a very different opinion, with reſpect to the modifications of the other colouring particles.

I have obſerved that the oxigenated muriatic acid exhibits different appearances with the colouring particles; that ſometimes it effaces the colour, and renders it white; that more frequently it changes it to a yellow, to a fawn, to a brown, and to a black, according to the intenſity of its action; and that when the colour appears to be effaced or bleached, heat, or the lapſe of time, are ſufficient to render them yellow.

I have compared the effect produced by the oxigenated muriatic acid, when the colouring particles are rendered yellow, fawn, or brown, with the effects of

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* Ann. de chym. tome V.

† Ibid. tome VI. Mem. ſur l'action que l'acide muriatique oxygéné exerce ſur les parties coloantes.

ſlight combuſtion, and I have found that they are perfectly the ſame; that they are owing to the deſtruction of the hydrogen, which, by combining with the oxigen more readily, and at a lower temperature than carbon, leaves it in a ſuperabundant quantity, ſo that the colour peculiar to the carbon is more or leſs mixed with that which exiſted before.

This effect is very evident, when we ſubject ſugar, indigo, an infuſion of gall nuts, or of ſumach, to the action of the oxigenated muriatic acid; the ſugar and indigo aſſume a deep colour, and preſent unequivocal marks of ſlight combuſtion; the infuſion of gall nuts, or of ſumach, affords a black depoſition, which is carbon almoſt pure.

Theſe phenomena are ſimilar to thoſe obſerved in the diſtillation of an organized ſubſtance; in proportion as the hydrogen is diſengaged under the form of oil, or in the ſtate of a gas, the ſubſtance becomes yellow, and at laſt there remains only a black charcoal. If we expell hydrogen from an oil by heat, it becomes equally brown.

By other experiments which I have made on alcohol and æther, I have proved that the oxigen united with the muriatic acid poſſeſſes the property of combining, and of forming water with the hydrogen, which abounds in theſe ſubſtances.

When then the oxigenated muriatic acid produces a yellow, fawn, or brown colour, this is occaſioned by the colouring ſubſtance undergoing a ſlight combuſtion, in which a greater or leſs portion of its hydrogen forms water, and then the carbon becoming the prevailing ingredient communicates its own colour.

I have made it appear, that it is upon this change of the colouring particles by the oxigen of the atmoſphere, by dew, and by the oxigenated muriatic acid, that the art of bleaching cloth is founded. The colouring particles of thread are rendered ſoluble by the alkaline ley, which ought to be alternate with the action of oxigen. We can afterwards ſeparate from the alkali theſe colouring particles, which being dried and brought together, are black, and demonſtrate the truth of this theory by the colour which they have aſſumed, and by the quantity of carbon which their analyſis affords.

The alkaline ſolution of the colouring particles of a cloth that is of a dark brown, loſes almoſt the whole of its colour, when a certain quantity of the oxigenated muriatic acid is poured upon it; and the ſame effect may be obſerved in many other ſubſtances that have aſſumed a colour which depends on the commencement of combuſtion.

A cloth may appear white, and yet become yellow in courſe of time; eſpecially if it is ſubjected to a certain degree of heat, when it has not been deprived of its oxigenated particles by a ley ſufficiently ſtrong: in the ſame manner, the green parts of vegetables are bleached by the oxigenated muriatic acid, but they become yellow by boiling.

Theſe acts prove that oxigen can whiten, or render the colouring particles paler with which it combines, whether it may have begun to produce the effects of combuſtion, or that it produces thoſe effects afterwards in a gradual manner; and eſpecially when their combination is ſubjected to a conſiderable degree of heat.

It is very probable, that in all theſe caſes, a part of the oxigen unites with the colouring particles without combining in a particular manner with the hydrogen; and that this is the reaſon why the colouring particles of thread become, by the action of oxigen, more ſoluble than formerly with alkalies.

The action of oxigen, in many other circumſtances, has certainly much influence upon the changes which are produced in the colouring particles of vegetables: theſe particles are formed chiefly in the leaves, in the flowers, and in the ſecond bark of trees: they gradually undergo a ſlight combuſtion, either by the action of the ſurrounding atmoſpheric air, or by that of the air which is carried into the interior parts of vegetables by the *vaſa propria:* hence the greater part of trees contain colouring particles of a fawn colour, approaching more or leſs to a yellow, red, or brown, which by means of this combuſtion are thickened and at length thrown out of the vaſcular fibres of the bark, of which I find they form the greateſt part.

Theſe obſervations inform us in what manner the air acts upon colouring ſubſtances of a vegetable or animal nature: it at firſt combines with them, weakens them, renders them pale, and by degrees excites a ſlight combuſtion, by which the hydrogen that enters into their compoſition is deſtroyed; they become yellow, red, or fawn; their affinity with the ſtuff appears to be weakened, they are detached from it, they are carried along by the water, and all theſe effects vary and are produced more or leſs readily, and more or leſs completely, according to the nature of the colouring particles, or rather according to the properties they poſſeſs in that ſtate of combination in which they exiſt.

The changes which happen in the colours that depend on the combination of the colouring particles with metallic oxids, are a compound effect of the change which is produced in the colouring particles, and of that which the metallic oxid undergoes.

The light of the ſun accelerates much the deſtruction of colours; it ought then (if the preſent theory be juſt,) to favour the combination of the oxigen, and the combuſtion by that means produced.

M. Sennebier has made a great number of intereſting obſervations with regard to the effects that light produces upon different ſubſtances, and particularly upon colours; he attributes theſe effects to a direct combination of the light with theſe ſubſtances *.

The influence of light upon the colour of wood has been obſerved for a great length of time: in the dark, it preſerves its natural ſtate, but expoſed to light it becomes of a yellow, a brown, and a variety of other ſhades. M. Sennebier obſerved the differences which occur in this particular between different kinds of wood: he found that the changes were proportional to the intenſity of the light; that they took place even under water, yet that moiſtened wood underwent theſe changes leſs readily than dry; that ſeveral folds of ribbon were neceſſary to preſerve the wood completely; that black paper was ſufficient; but that the

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* Mem. Phyſico chym. ſur l'influence de la lumiere ſolaire. T. c. 2.

the change was not prevented by other colours; that a ſingle fold of white paper was inſufficient, but that two intercepted the action of light.

This learned philoſopher has extended his experiments to a great number of vegetable ſubſtances, which may ſerve to explain many phenomena of vegetation that are foreign to our preſent ſubject. But in order to ſhow the action of the ſun upon colours, it will be ſufficient to examine the phenomena exhibited by the ſolution of the green parts of vegetables in alcohol.

If we expoſe to the light of the ſun this ſolution, which is of a beautiful green, it aſſumes an olive colour, which is afterwards in a few minutes deſtroyed: if the light has little intenſity, the effect takes place much more ſlowly; but in perfect darkneſs, the colour is preſerved without change, or at leaſt the change is very gradual. M. Sennebier ſays, that an alkali reſtores the green colour; but if the liquor has once been completely deſtroyed, the alkali produces no change in it. He obſerved, that in azotic gas, or phlogiſticated air, the colour was not changed; and that it ſuffered no change if the jar was full.

I inverted in mercury a jar half filled with a green ſolution, and expoſed it to the light of the ſun: when the colour was deſtroyed, the mercury was found raiſed in the jar, and conſequently vital air had been abſorbed; the oxigen had combined with the colouring particles. I did not obſerve the depoſition which M. Sennebier mentions; the liquor remained tranſparent, and was tinged of a clear yellow colour.

I evaporated this liquor, its colour inſtantly became deep and brown, the reſiduum was black, and in the ſtate of carbon.

The light then acted by promoting the abſorption of oxigen, and the combination of the colouring particles: at firſt, the marks of combuſtion were not perceptible, the liquor had only a feeble yellow colour, but the combuſtion was ſoon completed by the action of heat; the liquor became brown, and left a black reſiduum. If the veſſel in which the liquor is kept does not contain oxigenous gas the light has no action upon the colouring particles: the azotic gas does not ſuffer any diminution.

It is neceſſary to attend to an obſervation I have already made; ribbons, and a ſingle fold of white paper, do not prevent the action of light. It can penetrate through coverings which appear to us opake, and exert its influence to a greater or leſs depth.

Beccari, and after him M. Sennebier, have compared the effects that light produces upon ribbons of different colours; but the differences which they have obſerved ought rather to be attributed to the nature of the colouring ſubſtances with which the ribbons were dyed, than to the colours themſelves; for a ribbon dyed with braſil wood will loſe its colour much ſooner than one dyed with cochineal, although the ſhade be the ſame.

Although light accelerates greatly the combuſtion of the colouring particles, and its preſence even appears to be neceſſary to the deſtruction of ſome of them, yet in others this effect takes place without the aſſiſtance of light. Having placed in the dark, different

ent plants in contact with vital air, I obſerved that ſome of them abſorbed it. I alſo obſerved, that a roſe was changed and aſſumed a darker tinge without the contact of air, evidently becauſe it contained a ſmall quantity of oxigen, the combination of which afterwards became cloſer; but many kinds of flowers preſerved their colour perfectly in azotic gas.

I placed a quantity of the tincture of turnſole in contact with vital air over mercury in the dark, and another quantity in the light of the ſun; the former remained a long time without alteration, and without the vital air ſuffering any diminution; the latter loſt much of its colour and became red, the vital air was for the moſt part abſorbed and formed a ſmall quantity of carbonic acid, which evidently had changed the blue colour into a red.

This obſervation may give us an idea of ſome of the changes of colour that are produced by a particular diſpoſition of the principles exiſting in a vegetable ſubſtance, when by its combination with oxigen it experiences the effects of a ſlight combuſtion that may give riſe to ſome acid; in the leaves for example, which become red in Autumn before becoming yellow, and in the ſtreaks that are obſerved in flowers that begin to languiſh.

It is then proved that light favours the abſorption of oxigen by the colouring particles, and by this means combuſtion is produced, the common effect of which is a ſuper-abundance of carbonaceous particles.

We muſt attribute to the ſame cauſe the deſtruction obſerved in ſtuffs themſelves by the action of light. "Among many examples that I might quote, ſays Dufay, "I ſhall only mention a ſilk curtain of a "falſe crimſon colour, which had remained for a "long time ſtretched out behind a window; all the "parts oppoſite to the panes of glaſs were completely "faded, while thoſe that correſponded to the frame "were much leſs injured: beſides this, the ſilk itſelf "was almoſt deſtroyed in the faded parts, and the "curtain was torn with the leaſt force in theſe "places, while in others it preſerved nearly its uſual "degree of ſtrength *."

An apparent contradiction here preſents itſelf: it is to the action of the light of the ſun that the production of vegetable colours is owing; it diſengages oxigen from the nitric acid, from the oxigenated muriatic acid, from ſome metallic oxids, and from plants in vegetation; it produces then, to ſpeak ſo, the oppoſite of combuſtion, and when it contributes to the deſtruction of colours, it ſerves to fix the oxigen, and to produce a kind of combuſtion. In the ſame manner phoſphorus is not changed by the oxigenated muriatic acid in the dark, even with the aſſiſtance of heat; but it undergoes combuſtion, and is converted into phoſphoric acid by the preſence of light †.

I am ignorant what the circumſtances and what the affinities are that produce at one time the one effect, and at another time the other, but both are equally certain. It appears to me that theſe phenomena may be compared to thoſe of double affinities. It is certain that calcareous earth yields the ſulphuric acid to potaſh,

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* Mem. de l'acad. 1737.

† Mem. ſur l'acide marin dephlogiſtiqué, 1785.

potaſh, and yet by means of an exchange, calcareous earth can expell potaſh from its combination with ſulphuric acid.

I ſee, beſides, in nature a great number of phenomena of the ſame kind ; thus, in ſpirituous fermentation the hydrogen is accumulated in the liquor, and by the progreſs of the ſame effect alone the proportion of the hydrogen is diminiſhed ; it enters into combination with the oxigen, which becomes ſuperabundant when the fermentation paſſes to the acid ſtate. The putrefaction which takes place in animal ſubſtances may be conſidered as an operation oppoſed to the phenomena of growth and nutrition.

Colouring ſubſtances reſiſt then the action of air, in proportion as they are more or leſs diſpoſed to combine with oxigen, and to undergo by its action combuſtion more or leſs readily, and in a greater or leſs degree. The light promotes this combuſtion, and in many caſes it does not take place without its aſſiſtance; but iſolated colouring particles are much more diſpoſed to undergo this combuſtion than when they are combined with any ſubſtance, ſuch as alumine; whether it be that this defends them by its incombuſtibility, or to ſpeak ſo, that it reſtrains the force of their affinity, and weakens their action upon other ſubſtances ; it is in this that the utility of *mordants* chiefly conſiſts. In ſhort, this laſt combination acquires a ſtill greater degree of unalterability when it is intimately combined with the ſtuff.

Thus the colouring part of cochineal is readily diſſolved in water, and is ſpeedily changed by expoſure to the air : when it is combined with the oxid of tin, it is of a much more lively colour, and becomes almoſt inſoluble in water; but it is ſtill eaſily changed by the air, and by the oxigenated muriatic acid, and it reſiſts theſe agents better when it forms a triple combination with a piece of woollen ſtuff.

We muſt not conclude from what has been ſaid, that all yellow colours are owing to the carbonaceous part of colouring ſubſtances: very different compoſitions may produce the ſame colour; thus, indigo is very different from the blue of flowers, from the blue of the oxid of copper, and from Pruſſian blue.

I do not aſſert that oxigen cannot unite with certain colouring particles in a ſmall quantity, without weakening their colour, or changing them to a yellow. We ſhall ſee in the chapter on indigo, that it has a green colour when it is combined with an alkali, with lime, or a metallic oxid; but that it reſumes its colour, and is ſeparated from theſe ſolvents in recovering a ſmall portion of the oxigen which it had loſt. The liquor of the *buccinum*, which is employed to dye purple, is naturally of a yellowiſh colour, upon being expoſed to the air, and eſpecially to the ſun, it paſſes readily through different ſhades and aſſumes at laſt the colour that was ſo precious among the antients*.

We may conſider it as a general fact, that colours acquire a greater degree of brightneſs, by combining with a ſmall quantity of oxigen; it is on this account that it is neceſſary to agitate in the air ſtuffs which come out of the dying vat, and ſometimes to take them out at proper intervals to expoſe them to the air; but the quantity of oxigen which is fixed, and which contributes in this manner to the brightneſs of colours, is very inconſiderable in ſome, and the fading very ſpeedily commences.

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* Decouverte d'une nouvelle teinture de pourpre, &c. par Reaumur. Mem. de l'acad. 1711. According to the teſtimony of Eudocius the purple acquired its brightneſs, and arrived at perfection by expoſing it to the rays of the ſun.

The action of the air does not alter the colouring particles, and the ſtuff alone: it extends to metallic oxids when they are uſed as auxiliaries, becauſe the oxids, which are at firſt deprived of a part of their oxigen, may recover it again, as we ſhall ſee when we come to explain the action of aſtringents.

Thoſe which have a colour varying according to the proportion of oxigen, have a conſiderable influence upon the changes that the colour undergoes. The change obſerved in the blue produced on wool, by means of ſulphate of copper and logwood, is evidently owing to this cauſe.

This blue is changed very quickly to a green by the action of air; for we know that copper, which has a blue colour when it is combined with a ſmall portion of oxigen, acquires a green by combining it with a greater quantity of this principle. Indeed the change that the colouring particles undergo may contribute to produce this effect: but the colouring particles of logwood, which are naturally of a deep colour, ought during combuſtion to become brown rather than yellow, which would be neceſſary to produce green with blue.

I have ſaid that colouring particles which are in a a ſtate of combination, are leſs diſpoſed to be altered by the action of the air than when they are uncombined. This in general holds true. There are, however, ſome exceptions: alkali produces a contrary effect. I put an infuſion of cochineal in a jar, which I filled half full, and expoſed to the light over mercury. A ſimilar jar contained an infuſion of cochineal made with a ſmall quantity of tartar; and in a third jar I added to the infuſion a ſmall quantity of alkali: the infuſion in the ſecond jar ſuffered the leaſt alteration, and in it alſo the leaſt abſorption took place.

In the third, the liquor at firſt aſſumed a brown colour, which was afterwards deſtroyed; and the abſorption of air, although inconſiderable, was greater than in the other two. I had it evaporated; it aſſumed a brown colour, and the reſiduum was of a yellow brown.

I have made ſimilar experiments upon many colouring ſubſtances: an alkali deepens their colour which becomes darker, and it promotes the abſorption of air. Madder alone appears to be an exception to this: its colour, which at firſt becomes very deep, is better preſerved than that of the infuſion made without the alkali.

The common effect of the alkali upon the colouring particles is ſimilar to that which it produces upon many other ſubſtances, ſuch as ſulphur; it promotes the abſorption of the air, becauſe it has a ſtrong affinity with the reſult of this abſorption.

I explain by this action of the alkali an obſervation of M. Becker's, which is, that when an alkali has rendered a vegetable infuſion green, we ſee it gradually become yellow if we allow it to remain expoſed to the air, and when once the yellow is formed, acids cannot bring back the primitive colour again; but the ſame thing does not take place when we expoſe, during the ſame time, a vegetable colour that has been changed to a red by means of an acid. It is neceſſary, however, to except acids which may act by parting with their oxigen, as we ſhall immediately ſee, for then the colour is equally deſtroyed.

CHAP. IV.

Of the yellow colour produced in animal ſubſtances by the nitric and oxigenated muriatic acids.

THE action which the nitric and oxigenated muriatic acids exert upon animal ſubſtances, has ſuch a relation to the ſubject of the preceding chapter, that I have thought it proper not to ſeparate them, although the yellow colour which is produced by theſe acids upon wool, and particularly upon ſilk, might deſerve a place among the proceſſes of the art.

M. Brunwiſer * having obſerved that wood aſſumed different colours by expoſure to the air, endeavoured to aſcertain from what ſource theſe colours originated, and to produce them artificially: he obſerved, that by moiſtening the ſurface of wood, eſpecially young wood, which is not thoroughly dried, with the nitric acid, and it aſſumed a yellow colour; and that by repeating the ſame operation with the muriatic or ſulphuric acids it aſſumed a violet colour, and he conſidered this violet as compoſed of a blue and a red colour. From theſe obſervations he concludes, that ſince all colours are produced by the mixture of yellow, of blue, and of red, therefore thoſe which are obſerved in leaves, fruits, and flowers, muſt be owing to colouring particles which exiſt in the wood, and are concealed there by an alkali: that the mineral acids, by ſeizing upon this alkali, ſet the colouring particles at liberty; and that fixed air, by penetrating the leaves, fruits, and flowers, produces naturally the ſame effect by combining with the alkali that kept theſe particles concealed. This author has endeavoured to apply his experiments and ſuppoſed diſcovery to the arts *. After having moiſtened chips of wood with the nitric acid, he poured water upon them, filtrated the liquor, and employed it for dying ſtuffs made of wool, of ſilk, and goats hair, of a durable yellow; which is produced, according to him, by the yellow colouring particles contained in the wood being extracted or ſet at liberty by the nitric acid.

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* Verſuche mit mineraliſchen ſauern geiſtern aufden holzern farben zuziehen. 1770, in abhandlungen des Baieriſchen Academie,

De la Folie relates †, that having plunged a ſkain of white ſilk into the nitric acid, or aquafortis, of the degree of concentration at which it is ſold in the ſhops, in three or four minutes it took on a beautiful jonquil yellow colour: he waſhed it repeatedly with water,

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* Entdeckung verſchiedener vegetabiliſchen farbematerialen ſeiden und wollen zeuge ſchon und dauerhaft gelb zu farben 1771.

† Journal de Phys. T. IV. p. 349.

left it ſhould be altered by the acid that might remain adhering to it. This colour ſuſtained ſeveral trials to which he ſubjected it, and the ſilk preſerved its luſtre entire. When dipt into an alkaline ſolution, it aſſumed a beautiful orange colour.

We find many experiments upon this proceſs, in a diſſertation publiſhed by M. Gmelin [*]: he ſays, he gave a beautiful ſulphur colour to ſilk by keeping it for a day in cold nitric acid, or for a few hours when the acid was warm. Boiling with ſoap water diminiſhed the brightneſs of this colour. It was changed to a fine citron colour by keeping the ſilk for twelve hours in an alkaline ſolution, and it aſſumed a beautiful golden colour when this ſolution was warm.

All metallic ſolutions by the nitric acid give to ſilk a yellow colour more or leſs deep, as well as the ſolution of alumine by the ſame acid; but the ſolution of calcareous earth, or of magneſia, produces no effect.

This ſolution, mixed with the ſolution of gold, affords, according to la Folie [†], a purple colour, that is fixable upon ſilk; but M. Gmelin obtained by this proceſs only a common yellow. He proves alſo, that the different yellows which M. Struve had ſaid were obtained from metallic ſolutions [‡] are owing entirely to the acid of theſe ſolutions; the only exception that ought perhaps to be made is, with reſpect to the ſolution of mercury, which gives a copper colour to ſilk.

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[*] J. Frieder. Gmelin, prof. Gotting, de tingendo per nitri acidum, ſive nudum, ſive terrâ aut metallo ſaturatum ſerico. Erfurti 1785.

[†] Journ. de Phyſ. T. VIII.

[‡] Berneriches magazin der naturkunſt und wiſſenſchaften, vol. 1.

Bergman was acquainted with this proceſs when he publiſhed his notes to the treatiſe of Scheffer*: he ſays, that common aquafortis gives to wool and to ſilk, in three or four minutes, a clear, beautiful, and durable yellow; that it is neceſſary to waſh them both immediately, and that the more the acid is dephlogiſticated, the greater is the effect that is produced.

From the firſt experiments that I made upon the oxigenated muriatic acid, I found it had alſo the property of giving a yellow colour to animal ſubſtances; but it gave them a colour much leſs deep than the nitric acid, and it injured them much more than this acid when properly diluted with water, ſo that the nitric acid is greatly preferable for the purpoſes of art.

To reſume theſe obſervations; the nitric acid, diluted with a certain quantity of water, gives to ſilk a yellow colour, more or leſs deep, according to the concentration of the acid, the temperature, and the longer or ſhorter time of immerſion; it is neceſſary to waſh the ſilk carefully on taking it out of the acid: this colour has a ſufficient degree of brightneſs: it may be rendered deep without any viſible injury to the ſilk, ſo that this proceſs may be of real uſe. The colour may be modified by alkalies.

The ſolutions of calcareous earth, or of magneſia, produce no effect upon ſilk, becauſe they do not contain an exceſs of acid; the ſolution of alumine, and thoſe of all metallic ſubſtances, produce, on the contrary, a darker or lighter yellow; becauſe they all contain

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* Eſſai ſur l'Art de la Teinture.

tain a greater or leſs exceſs of acid, which acts upon the ſilk in the ſame manner as a free acid: it was the acid alone, therefore, which gave the yellow colour to animal ſubſtances in the experiments of M. Brunwiſer, and not the particles extracted from the wood.

The yellow colour is not owing to iron, as de la Folie has alledged; for the pureſt nitric acid, which of conſequence contains no iron, produces it as well as that in which a ſmall quantity of this metal is ſuppoſed to exiſt.

If we put ſilk into concentrated nitric acid, it readily aſſumes a deep yellow colour, loſes all its force of adheſion, and is diſſolved: during this ſolution, the azote, which enters into the compoſition of animal ſubſtances, is diſengaged, and occaſions a tedious effervеſcence *: if we apply heat, a great quantity of nitrous gas is diſengaged, and at the beginning the liquor aſſumes a deep colour, and becomes brown. At this time the oxigen of the nitric acid combines unqueſtionably with the hydrogen that abounds in animal ſubſtances, which aſſiſts in forming the oil we obtain from them in diſtillation, and which renders them ſo inflammable. The ſame effect ought to take place when the acid begins to act upon the ſilk and to render it yellow. I believe, therefore, that the yellow colour ariſes from an incipient combuſtion, as I have explained in the preceding chapter. This ſlight degree of combuſtion does not injure the ſilk in any ſenſible manner; but if the acid is too much concentrated, if the immerſion is continued too long, or if we

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* Mem. de l'Acad. 1785.

we do not remove, by a careful waſhing, whatever might adhere to it, the ſilk is ſoon very much injured, and, according to common language, which affords a very juſt idea, *it is burned.*

We can now perceive why, according to the obſervation of Bergman, the nitrid acid, which he called the dephlogiſticated, is for this operation to be preferred to that which is ſaturated with nitrous gas: for in the former the proportion of oxigen being greater, it is on that account more fit to produce the effects of combuſtion until it is brought back to the ſtate of nitrous acid.

The ſame circumſtance ought undoubtedly to explain the action of the oxigenated muriatic acid upon animal ſubſtances; yet it differs in ſome eſſential points, all of which I cannot explain, as they require a great number of obſervations.

Silk aſſumes, with the oxigenated muriatic acid, a colour much lighter than with the nitric: the ſulphurous acid cauſes it in a great meaſure to diſappear, but it has no action upon the yellow produced by diluted nitric acid. The oxigenated muriatic acid has, however, a much more lively action upon ſilk: it quickly injures it, and even diſſolves it: if we allow the ſilk to remain ſome time in this liquor, the yellow, which at firſt appears, is weakened, agreeably to the obſervation I formerly made, that the yellow colour, which is owing to the combuſtion firſt produced, may be diſguiſed by the accumulation of oxigen.

By the readineſs with which the ſulphurous acid parts with its oxigen, I once endeavoured to explain * the

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* Suite des Exper. ſur l'acide ſulfureux. Ann. de Chym. tom. II.

the effects it produces upon colours, and I compared them to thoſe of the oxigenated muriatic acid; and although it be true that oxigen adheres much more weakly to the ſulphurous than to the ſulphuric acid, yet I do not believe that the explanation I gave is well founded.

According to the obſervation of de la Folie *, roſes whitened by the vapour of burning ſulphur, become green in an alkaline ley, and red in acids. I have myſelf obſerved, that the ſulphurous acid reddens the tincture of tournſole, which has a very fleeting colour, and that it acts only like other acids upon infuſions of yellow wood, on fernambouc, and logwood. I have beſides obſerved, that ſilk which has been expoſed to the vapour of ſulphur, exhales the odour of ſulphurous acid, when we moiſten it with the ſulphuric, although this odour was not formerly perceptible.

I think then, that the ſulphurous acid combines generally with the colouring particles and with ſilk, without parting with its oxigen to them, and conſequently without combuſtion taking place; that the reſult of this combination ſometimes loſes all colour, a property depending probably on the ſemi-elaſtic ſtate of the oxigen; but ſometimes the combuſtion may take place, and it ought in general to do ſo by degrees; ſo that the colouring particles, after having been long concealed, will at laſt aſſume a yellow colour. This ſubject I think might eaſily be elucidated by ſome experiments.

CHAP.

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* Journ. de Phyſ. 1774.

CHAP. V.

Of Aſtringents in general, and particularly of Galls.

ASTRINGENTS deſerve particular attention, not only becauſe they are of great uſe in dying, but becauſe they exhibit a property common to a great number of vegetables.

There is, perhaps, no property in vegetables of which we entertain ſuch vague ideas as of this; we often judge of it from a weak reſemblance in the taſte, and both in medicine and in the arts under the name of aſtringent, we rank alum and many vegetables, the properties of which are, however, exceedingly different: in general, we conſider as an aſtringent, every ſubſtance which gives a black colour to a ſolution of iron; we ſuppoſe, that this effect is owing to one and the ſame principle exiſting in all the ſubſtances which produce it: we apply the term aſtringent to this principle, and at preſent it is conſidered as a peculiar acid to which we give the name of gallic acid, from the gall nut in which it exiſts.

However, ſeveral learned chemiſts have of late made a great number of intereſting obſervations upon aſtringents. I ſhall now preſent an abſtract of them; but as the gall nut has been the uſual ſubject of theſe obſervations, it is neceſſary to begin by deſcribing it.

The gall nut is an excreſcence which is found upon the young branches of the oak, particularly on the ſpecies that we call the hard oak, which grows in the Levant, Iſtria, Provence, and Gaſcony. This excreſcence is produced by the bite of an inſect, which depoſits its eggs in the ſmall inciſion it makes in the Spring; the juice which tranſudes from this wound thickens, accumulates, and ſerves as a ſhelter to the young inſect, until it be able to make its eſcape: when the inſect does not obtain an outlet, we find it dead in the gall nut: ſometimes after it has quitted its habitation, other inſects enter and occupy it.

There are different kinds of gall nuts; ſome of them are white, yellow, green, brown and red; others are aſh-coloured and blackiſh; they vary greatly in ſize; they are round or irregular, light or heavy; ſome of them are ſmooth, and others are covered with knobs: thoſe which are ſmall, knobby, blackiſh, and heavy, are the beſt: it is theſe laſt that are known by the name of the galls of Aleppo, and they are brought from Aleppo, Tripoli, and Smyrna.

Galls are almoſt entirely diſſolved by long boiling: ſixteen drachms afforded to Newman fourteen drachms of extract; alcohol diſſolved only four grains of the reſiduum, which weighed two drachms.

The ſame quantity, infuſed firſt in alcohol, and afterwards in water, afforded twelve drachms two ſcruples of a ſpirituous, and four ſcruples of an aqueous extract; the reſiduum weighed half a ſcruple more than in the preceding experiment. The ſpirituous extract had a ſtronger and more diſagreeable taſte than the other *.

M. Monnet, to whom chemiſtry is indebted for a great number of important obſervations †, conſiders

Macquer

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* The chemical works of Caſpar Newman, by William Lewis.

† Traité des Eaux minérales, p. 304.

Macquer as the firſt who attributed the formation of ink to a precipitation of iron by the aſtringent principle, the theory of which he has himſelf eſtabliſhed; he imagines that the iron has a greater affinity to this principle than to the acid with which it was united; but the acid diſſolves a part of the precipitate, provided it be not too much diluted with water.

Iron is not the only metallic ſubſtance which may be precipitated from its ſolvent by the aſtringent principle: M. Monnet has obſerved, that gold, ſilver, copper, zinc, cobalt, platina, and mercury, are alſo precipitated by it.

The metallic ſubſtance the moſt eaſily precipitated is mercury: its ſolution mixed with an infuſion of galls aſſumes a brick colour, but the precipitate which is formed ſoon becomes of a reddiſh grey.

Copper is very readily precipitated: the precipitate is at firſt green, but it becomes of an aſh-coloured grey, and in drying aſſumes a reddiſh coppery gloſs.

Zinc forms a green aſh-coloured precipitate.

The precipitate of cobalt is of a clear blue; but it does not preſerve this colour long, for it ſoon becomes of an aſh-coloured grey.

Silver is precipitated very ſlowly: the precipitate, which is at firſt of the colour of burnt coffee, aſſumes, when dried on paper, a ſhining ſilvery luſtre.

Gold is precipitated almoſt inſenſibly: the precipitate, when collected and dried, is in every reſpect ſimilar to that of Caſſius.

M. Monnet collected the precipitate of iron by the aſtringent principle upon a filter: it was of a beautiful deep blue: he thinks it might be employed with advantage in painting. He tried to diſſolve it in the nitric and ſulphuric acids, but they acted upon it very ſlowly; having accelerated their action by heat, he obtained by filtration beautiful yellow tinctures, eſpecially that of the nitric acid, which reſembled a ſolution of gold: no precipitation took place, and the liquors remained always clear and limpid: alkali occaſioned no precipitation; it produced only a deeper colour. M. Monnet was led by this obſervation, to diſſolve this precipitate directly in a ſolution of fixed alkali by means of boiling; he obtained a ſolution as red as blood, in which water produced no precipitation.

The academicians of Dijon have added to theſe facts ſeveral intereſting obſervations.

Galls afford by diſtillation, a limpid phlegm, which gradually becomes brown, then a yellow oil, after that an oil deeper in colour, and empyreumatic. All theſe liquors afford a black precipitate with the ſulphate or vitriol of iron; the carbonaceous reſiduum has no longer any peculiar property; it reddens in the fire without being reduced to aſhes.

Even cold water diſſolves the aſtringent principle: an ounce of galls afforded by this means three drachms of a nondeliqueſcent and very ſtyptic extract.

Fixed and volatile oils and æther diſſolve the aſtringent principle.

The infuſion of galls gives a red colour to blue paper, and the tincture of tournſole; but it has no action upon ſyrup of violets.

The ſulphuric acid receives from galls a red colour; the nitric an amber, and the muriatic a brown: theſe three acids precipitate the ſulphate of iron of a black colour, when they are ſaturated with alkalies.

The acetous acid loaded with the aſtringent principle, does not require this addition of alkali to give a black precipitate.

The phoſphoric acid produces no change upon the infuſion of galls; but this mixture renders the ſolution of ſulphate of iron muddy, and a white precipitate is formed.

The ſulphure of alkali is decompoſed by the infuſion of galls: in filtrating the liquor afterwards, the reſiduum does not precipitate the iron of a black colour, but the liquor that paſſes through the filter produces this effect; it appears to be a combination of alkali and of the aſtringent principle.

The carbonate of fixed alkali gives a reddiſh colour to the infuſion of galls: this mixture forms a brown precipitate with the ſulphate of iron.

The cauſtic alkali gives a red brown colour to the infuſion of galls; and precipitates, at the ſame time, the ſulphate of iron of a black colour: this precipitate when properly waſhed is not attracted by the magnet: it diſſolves without efferveſcence in the mineral acids, but is not acted on by the acetous.

The mixture of the pruſſiate of alkali, and of the tincture or alcohol of galls, affords a black precipitate with the ſolution of iron: the ſulphuric acid at firſt augments the intenſity of the colour, and at laſt deſtroys it.

The ſame work contains a great number of obſervations upon the precipitation of metallic ſubſtances by the aſtringent principle: galls do not alter the ſolutions of arſenic in any degree; and the oxid of this metal, mixed with an infuſion of galls, does not prevent its action upon iron. The aſtringent principle forms ink with all the acid ſolutions of iron, except thoſe of the phoſphoric and arſenical acids.

To conclude; we find in that work ſome experiments upon ink, and upon the depoſition which it affords when largely diluted with water. Ink is not decompoſed by the acetous acid, but the mineral acids quickly deprive it of its colour; the ſulphuric acid produces heat in it without effervesſcence; the liquor becomes yellow, and forms a greyiſh depoſition. Alkalies reſtore the colour that acids have made to diſappear, but by repeating the alternate action of the acids and alkalies, the colouring principle is at length deſtroyed.

The ſame academicians have obſerved another fact, which may become important, and upon which we ſhall afterwards ſee M. Laval has beſtowed more attention; it is the action of galls upon iron. A cold infuſion of them gives a violet tinge to iron filings, but by boiling them together, a part of the iron is diſſolved, and the liquor aſſumes a violet colour, which approaches much to a black.

M. Laval ſays, he long ago obſerved, that galls infuſed in diſtilled water alone, diſſolve iron with the greateſt readineſs; that with a ſimple ſolution of this metal in an infuſion of galls, he not only produced the deepeſt black colour, and the moſt indelible ink, but alſo, by plunging ſilks and woolen ſtuffs into this black tincture, he dyed them, without the addition of any acid, of the deepeſt and moſt indeſtructible black.

Dr Prieſtley obtained inflammable, or hydrogenous gas, from a mixture of iron filings, powdered galls and water: this experiment proves, that galls act upon iron like acids, by promoting the decompoſition of water, and the conſequent diſengagement of its hydrogenous gas.

Even before M. Monnet aſcertained the manner in which the aſtringent principle combines with the iron, and forms the black colouring particles which may be precipitated, Dr Lewis had made ſome intereſting obſervations upon this combination, which he endeavoured to render peculiarly uſeful in the arts.

He obſerves, that if we dilute common ink with a ſufficient quantity of water, the black is precipitated, and the liquor remains clear; he remarks, that it is this black part which is fixed upon ſtuffs, and which ſerves to colour them: he endeavoured from this to determine the moſt convenient proportions of the aſtringent, and of the ſolution of iron, both as to the quantity of the black precipitate, and as to its quality.

The experiments of Scheele have ſuch an influence on the opinion that is formed concerning the nature of the aſtringent principle, that I ſhall relate them in his own words:

"I paſſed through a large ſieve a pound of galls, "and infuſed the powder with 2 and 3-4ths pints "of water in a glaſs globe. I allowed it to remain in "that ſtate four days, during which time it was fre- "quently ſtirred with a glaſs reed. I filtrated the li-

" quor, which was clear, and of the colour of French " wine: I expoſed it to the open air in the ſame glaſs " globe, covered only with a bit of grey paper. This " preparation was made in the month of June. A " month afterwards I again looked at this infuſion, " and I found it covered with a thick mouldy pelli- " cle; there was no precipitate formed, and it had a " more acid, but not more aſtringent taſte than for- " merly. I replaced this infuſion in the ſame globe, " covered as formerly with grey paper. Five weeks " after this I examined it again; almoſt one half of it " was evaporated. I found a precipitate two inches " in thickneſs, and on the ſurface a mucous pel- " licle; it had loſt wholly its ſtyptic taſte, although " it ſtill gave a black colour to the vitriol of iron. I " filtrated the infuſion, and expoſed it once more to " the open air: by the following Autumn the great- " eſt part of it was evaporated; what remained was " mixed with a great quantity of precipitate. I mix- " ed all theſe precipitates together, and poured cold " water upon them; after they had been depoſited, I " decanted off the liquor, and poured on as much " warm water as was neceſſary for their ſolution.

" I filtrated the whole; the liquor was of a brown " yellow; I evaporated it with a gentle heat; during " the evaporation a part like fine ſand was precipita- " ted; another part formed cryſtals at the bottom " diſpoſed towards the light; this ſalt was of a green " colour, and notwithſtanding repeated ſolutions and " cryſtallizations, it was impoſſible to procure it " whiter.

" This ſalt of galls has the following properties:

"1. It has an acid taſte: effervefces with chalk, "and gives a red colour to the infuſion of tournſole.

"2. An ounce and a half of water are required "to diſſolve half an ounce of this ſalt completely; but "as ſoon as the ſolution becomes cold, the whole "forms a concrete maſs, compoſed of ſmall cryſtals. "Half an ounce requires twelve ounces of cold water "to diſſolve it.

"3. It diſſolves very readily in ſpirit of wine: for "half an ounce of this ſalt, only the half of boiling "ſpirit of wine is neceſſary; but if we uſe cold ſpirit "of wine, two ounces are required for half an ounce "of the ſalt.

"4. It burns readily in an open crucible on the "fire, and in melting exhales an agreeable odour; but "it afterwards affords a charcoal that is with difficulty reduced to aſhes.

"5. Diſtilled in a retort it becomes at firſt fluid, "and affords an acid phlegm. No oil comes over, but "towards the end a white ſublimate riſes which attaches itſelf to the neck of the retort, and remains "fluid as long as it is warm; but it afterwards cryſtalliſes; we find in the retort a great quantity of charcoal. This ſublimate has almoſt the ſmell and taſte "of the benzoinic acid, or ſalt of benzoin: it diſſolves "as readily in water and in ſpirit of wine; it reddens "the infuſion of tournſole; and, what is very remarkable, it precipitates metallic ſolutions of their different colours and the vitriol of iron of a black.

"6. The ſolution of the ſalt of galls poured into a "ſolution of gold, gives it a dark green colour, and

" at laſt a powder is precipitated, which is the gold " revived.

" 7. The ſolution of ſilver becomes brown, and " depoſits by heat a greyiſh powder, which is the ſil" ver revived.

" 8. The ſolution of mercury is precipitated of an " orange yellow.

" 9. The ſolution of copper affords a brown pre" cipitate.

" 10. The vitriolic ſolution of iron becomes black; " the more water that is added, the colour becomes " deeper.

" 11. Lead diſſolved in vinegar is precipitated of a " white colour.

" 12. Biſmuth gives a yellow citron precipitate.

" 13. The molybdenic acid becomes of an ob" ſcure yellow colour, without affording any precipi" tate.

" 14. Platina, zinc, the arſenical acid, tin, cobalt, " and mangaueſe, do not ſuffer any change.

" 15. The ſolutions of lime, magneſia, alumine, " and barytes, are not decompoſed, but lime-water " affords a copious gray precipitate.

" 16. The ſalt of galls is converted into the ſac" charine acid by diſtilling nitrous acid upon it in the " uſual manner.

" The white precipitate that we obtain when the " acetite of lead is precipitated by galls, may be again " decompoſed by the vitriolic acid, and we obtain the " ſalt of galls in its greateſt purity: however, as the " infuſion of galls precipitates the acetite of lead, I " thought I ſhould have been able to have procured

" this ſalt in a manner ſtill more expeditious; but " this did not ſucceed; for when I had decompoſed " this precipitate by means of the vitriolic acid, " I again found my infuſion of galls poſſeſſed of " its ordinary aſtringent taſte. If we diſtill galls with " a violent fire, we obtain an acidulated phlegm, the " odour of which is not diſagreeable: no oil paſſes " over; but towards the end a volatile ſalt riſes, ſimi- " lar to that obtained from the diſtilled ſalt of galls, " and poſſeſſed of the ſame properties. From this it " appears, that this ſalt exiſts completely formed in " the infuſion of galls, although it cannot be obtain- " ed by means of ordinary cryſtallization; for it is ſo " intimately combined with ſome mucilaginous or " other matter, that it cannot be ſeparated without " an internal commotion, or without fermentation."

Theſe experiments of Scheele have induced the greater part of chemiſts to conſider the gallic acid as the aſtringent principle, and to conclude that it exiſts in all vegetable ſubſtances which precipitate ſolutions of iron of a black colour; that this precipitate is a combination of the gallic acid, and of the iron which quits the other acids to unite with it.

I have repeated and varied the experiments of Scheele upon galls, and I have obſerved, 1. That by following the proceſs pointed out by this great chemiſt there were green pellicles ſucceſſively formed, owing to a *byſſus* which could not be produced in a veſſel well ſtopped.

2. That in a ſimilar veſſel where evaporation could not take place, pure, tranſparent, and yellow cryſtals were depoſited during the Winter, without

the influence of the external air, and that conſequently the gallic acid exiſts in the galls, and is not produced by the abſorption of oxigen, as I had formerly conjectured.

3. That if we evaporate one half of the liquor before ſhutting it up in the veſſel, it aſſumes a deep colour during the evaporation, and depoſites afterwards a great quantity of a cryſtalline ſubſtance, but leſs pure, and of a deeper colour.

4. That the acid obtained in this manner, or by the proceſs of Scheele, and afterwards diſſolved in water, is always decompoſed by evaporation; that black pellicles are ſeparated from it; that it becomes brown by ſimple expoſure to the air; that, after repeated operations, nothing more is obtained than an ill-formed cryſtallization of a grey colour, more or leſs yellow or brown; and that if the evaporation is repeated a number of times, this ſalt is completely deſtroyed. Heat, and eſpecially boiling, accelerate this deſtruction: this is the true reaſon, I believe, why this ſalt is not obtained by evaporating the decoction of galls: an extract then remains which reſembles perfectly that of galls, and which ſuddenly precipitates ſolutions of iron of a black colour.

5. The ſolution of the gallic acid aſſumes a fine green colour with the fixed and volatile alkalies, either free or combined with the carbonic acid; and this colour becomes ſo deep, that it appears black if the gallic acid and the alkaline ſolution are brought together: with lime water the gallic acid aſſumes a reddiſh brown colour, the red tinge is diſſipated, and

a copious depoſition takes place of a grey colour, approaching to brown.

In the mixture of the gallic acid with the carbonate of alkali, I have not obſerved an effervefcence, any more than with the carbonate of lime or of magneſia: but this ſubſtance reddens the tincture of tournſole, of radiſhes, &c. like acids.

6. The infuſion of common galls produces the ſame effect upon vegetable colours as the gallic acid, but the infuſion of white galls has no action upon them.

Paper tinged with tournſole is not altered by the infuſion of ſumach, of the bark of the plumb-tree, of the bark of the walnut, or of Peruvian bark.

Having made four ſucceſſive decoctions of galls, which had previouſly undergone Scheele's proceſs, the two laſt did not redden paper tinged with tournſole, although they precipitated copiouſly the ſolutions of iron. By ſpontaneous evaporation I could perceive no mark of the gallic acid in the two laſt decoctions.

7. A ſolution of the ſulphate of iron, mixed with a ſolution of the gallic acid of the higheſt poſſible degree of purity, is not diſturbed, and does not aſſume any colour at firſt; it is only by degrees that it becomes black, without loſing its tranſparency, or at leaſt it does not begin to loſe it till after ſome hours: a ſmall quantity of the infuſion of galls produces inſtantaneouſly a colour much more intenſe and opake.

Theſe obſervations prove, in a ſatisfactory manner, that it is not the gallic acid that communicates the aſtringent property to the ſubſtances which poſſeſs it: that this acid itſelf poſſeſſes this property in a lower degree than other aſtringents.

Indeed

Indeed the ſumach, which is managed like galls by Scheele's proceſs, does not afford any gallic acid, although it poſſeſſes the aſtringent property in a high degree; the green ſhell of nuts treated in the ſame manner alſo gives none. It appears that the property, which the infuſion of common galls has of reddening certain vegetable colours, depends entirely on the gallic acid; ſince the infuſion of ſumach, that of the bark of the plumb-tree, which readily afford a black precipitate, the infuſion of the bark of the walnut, and of the Peruvian bark, do not poſſeſs this property; and from this it appears, that the gallic acid does not exiſt in white galls. The infuſion of white galls expoſed to the air may readily deceive us; for it forms a copious precipitate, but this is not the gallic acid.

If the aſtringent property were owing to one and the ſame principle, diſtributed among different vegetables, the precipitates that are obtained by their means from a ſolution of iron ſhould be the ſame combination, and ſhould preſent the ſame appearances and the ſame properties: but it is quite otherwiſe; the precipitate produced by galls is of a blackiſh blue; that from logwood has another ſhade of blue; that from the oak is of a fawn, or blackiſh brown; that from the Peruvian bark of a blackiſh green: the circumſtances which attend their depoſition are different, and when fixed upon ſtuffs, ſome of them are deſtroyed much more readily than others by alum and tartar. It cannot be doubted, that by multiplying the experiments, we ſhall ſtill find many remarkable differences among the properties of theſe various precipitates.

Aſtringents then form different kinds of combinations with iron, and conſequently their aſtringent property does not depend upon one and the ſame principle exiſting in different vegetables; ſtill, however, there muſt be ſome property common to theſe different ſubſtances, which enables them to act in the ſame uniform manner upon ſolutions of iron, and to produce precipitates, which being more or leſs black, appear to be of the ſame nature, at leaſt when not examined with attention.

I have obſerved, in analyſing the effects of *mordants*, that metallic oxids, by combining with the colouring particles, modify their colours; but the colour of ſome metallic oxids, and particularly of the oxid of iron, varies according to the quantity of oxigen which they contain. Iron combined with only a ſmall portion of oxigen is of a black colour, and forms what we call martial æthiops. It is ſufficient that a ſubſtance, in combining with an oxid of iron, be able to ſeparate from it a part of the oxigen which it retains, when precipitated from an acid ſolution, in order to give it a black colour; and if the particular colour of this ſubſtance does not predominate, or if it approaches to black, the combination which is formed will be black alſo.

Thus nitrous gas, free, or weakly combined in the nitrous acid, blackens the ſolutions of iron, as I have already ſhown *, and it precipitates this metal by depriving it of a part of its oxigen.

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* Mem. de l'acad. 1785, p. 338. The cauſe of the production of black by the gallic acid, has not eſcaped the ſagacity of M. Fourcroy; "it colours iron," ſays he, "becauſe it makes it "approach to the metallic ſtate."

It is alſo by acting in this manner that ammoniac forms a black precipitate with the ſolutions of iron ; for the hydrogen of the ammoniac forms water with the oxigen that is taken from the oxid of iron.

But galls, according to the obſervations of M. Monnet, and the academicians of Dijon already quoted, precipitate ſilver and gold from their ſolutions, by reſtoring them to the metallic ſtate. They have then the property of abſtracting oxigen from thoſe metals to which it adheres ſlightly, and of taking from others the portion that is leaſt intimately combined.

The infuſion of galls itſelf aſſumes readily a deep brown colour, by remaining expoſed to the air ; however, I have found that it does not abſorb much oxigen. The infuſion of ſumach, and thoſe of moſt other vegetable ſubſtances, particularly of woods and barks, aſſume in the ſame manner a brown colour by expoſure to the air : ſo that by acting upon the oxid of iron, and by abſtracting a part of its oxigen, an aſtringent ought itſelf to aſſume a brown colour which muſt concur in producing the black.

We ſee then, why many ſubſtances, which in other reſpects have different properties, may produce black with the ſolutions of iron. Among theſe ſubſtances, there are ſome which have true colouring particles, and which are employed as ſuch in dying : for example, logwood, and even the greater part of colouring particles, form brown or blackiſh precipitates with iron. Sometimes the aſtringent effect is not inſtantaneous, but only produced by degrees ; the colour of the precipitate is at firſt clear, it deepens, and becomes brown gradually, in proportion as it loſes its oxigen: we obſerve this in the infuſion of yellow wood; with a ſolution of iron, it forms a yellow precipitate, which gradually becomes brown, and afterwards black,

Although the property of precipitating ſolutions of iron of a black colour, does not announce the exiſtence of one and the ſame principle in the ſubſtances which poſſeſs it, yet it may not be improper to expreſs it by the name of the aſtringent principle, provided we underſtand by this word only a property common to a great number of ſubſtances, and a property which may exiſt in them in very different degrees.

The aſtringent principle precipitates iron from almoſt all acids; it appears from the experiments of the academicians of Dijon, that the phoſphoric and arſenical acids alone, have a greater affinity with it than the oxid of iron, and we know that the phoſphoric acid has the property of ſeparating iron from the ſulphuric acid; but all acids re-diſſolve this precipitate, and make its colour diſappear until they be ſaturated with an alkali, except the acetous acid; and probably the other vegetable acids that have not yet been tried.

We need not be ſurpriſed, that the aſtringent principle can combine with metallic oxids without poſſeſſing the qualities of an acid; for animal ſubſtances, oils, and even alkalies, and lime, have the ſame property.

It is this precipitate compoſed, of iron and the aſtringent principle, which, by remaining ſuſpended in the liquor, forms ink; an object that is ſufficiently intereſting both on its own account and its connection with dying black, to arreſt our attention for a moment.

When we pour a ſmall quantity of the ſolution of iron into an infuſion of galls, at firſt we perceive the liquor become black at the point of contact; but the precipitate which is formed, is re-diſſolved in the aſtringent liquor; by continuing to pour a ſufficient quantity of the ſolution of iron, all the liquor becomes black, and loſes its tranſparency; if in this ſtate we dilute it with a very great quantity of water, the precipitate is gradually depoſited, but the depoſition is very ſlow in forming, when we uſe only a ſmall proportion of the ſolution of iron; on the contrary, it forms much more readily, if we employ a quantity of the ſolution of iron ſo great, that all the aſtringent principle may combine with it. A ſuperabundance of the ſulphate of iron alſo accelerates this effect. The ſame phenomena take place here which are obſerved in other precipitations. The precipitate which is formed is ſoluble to a certain degree in the aſtringent ſolution; when the ſolution is farther advanced, the precipitation begins; but the precipitate is ſtill kept ſuſpended until the action of the aſtringent principle is ſufficiently weakened by the admixture of water; if the iron is in a quantity ſufficient to exhauſt the action of the aſtringent principle, the precipitate is not retained, but depoſited much more quickly.

The gum we add to ink oppoſes the depoſition of the colouring part; it ſerves to fix more of this colouring part to a ſingle ſtroke of the pen, to prevent it from running, and to preſerve it from the action of the air. The gum of the cherry and plumb trees, according to Lewis, anſwers as well as gum-arabic.

The principles which I have eſtabliſhed ſerve to explain ſeveral obſervations that Lewis has made upon this ſubject, and of which I ſhall now relate the principal.

Ink that is made by ſimple infuſion is of a pale colour, and becomes black only by keeping: but if we wiſh to have it at once a black ink, it is neceſſary to imitate the dyers, who boil the aſtringents in water for a long time, and afterwards add the ſulphate of iron: for, 1. By boiling, we diſſolve a greater quantity of the aſtringent principle; 2. By adding the ſulphate of iron to the liquor, while ſtill very warm, we more readily obtain an effect analogous to the ſlight combuſtion that takes place, when the oxigen combines with the aſtringent principle.

Recent ink, as well as ſtuffs immediately taken out of the dying vat, aſſumes always a deeper black by the contact of air; it appears, that this effect is owing to the oxigen which the galls ſeparate from the iron, not being ſufficient for the degree of combuſtion neceſſary to produce the black required; and that this combuſtion is completed by the oxigen which is attracted from the atmoſphere.

Ink, in the formation of which a large proportion of the ſulphate of iron has been employed, readily becomes brown by the action of the ſun, and of the air, and at laſt yellow; becauſe the iron which is not ſaturated with the aſtringent principle continues to attract powerfully the oxigen, and by this it loſes its black colour, and aſſumes one that approaches more and more to a yellow; and, at the ſame time, the combuſtion of the aſtringent principle proceeds rapidly, eſpecially by the influence of light; but the ink is much more durable if the aſtringent principle exiſts in a ſufficient proportion.

The beſt, according to Lewis, is compoſed of three parts of galls and one of the ſulphate of iron. He found that characters which had become brown or yellow, recovered their colour in conſequence of being moiſtened by an infuſion of galls. Dr Blagden has uſed the pruſſiate of alkali with ſucceſs to recover writings worn out by age, and he found it more advantageous than galls.

Although chemiſts have conſidered the aſtringent as one and the ſame principle, experience has ſhown that all aſtringent ſubſtances are not equally fit for producing a beautiful and ſolid black: it is of conſequence to aſcertain thoſe which may be employed with ſucceſs; but it muſt be obſerved, that it is very difficult to give preciſion to comparative experiments made upon this ſubject, becauſe ſome ſubſtances require much longer boiling than others for the extraction of the aſtringent principle; and the finer or coarſer form under which we ſubject theſe ſubſtances to boiling, may afford different reſults; and becauſe the colouring particles have a ſtronger or weaker diſpoſition to combine with the ſtuff, according to the proportions of the ſulphate of iron that have been employed.

It is neceſſary alſo to obſerve, that the ſolutions of iron by different acids may produce variations in the reſults, according to the more or leſs oxigenated ſtate in which the iron exiſts, according to the greater or leſs proportion of this metal, and according to the ſtronger or weaker action that the different acids, now ſet at liberty, may exert upon the combination which is formed. Laſtly, in the dying of a piece of ſtuff, the ſtronger or weaker affinity of the ſtuff for the colouring particles, may alſo produce changes in the reſults.

Lewis has obſerved, that the decoction of logwood uſed inſtead of ſimple water for the infuſion of galls, increaſes the beauty of the ink without rendering it more pale. Sumach, the bark of the plumb, the pomegranate, the flowers of the pomegranate, the roots of biſtort, tormentil, the bark of the oak, do not poſſeſs the efficacy of galls. In his experiments on dying, he found that ſumach, the bark of the oak, and the ſaw-duſt of the ſame wood, could only ſupply the place of galls, by employing them in larger proportions.

M. Beunie has publiſhed a great number of intereſting experiments *; his object was, to determine the beſt method to dye cotton of a fixed black. He tried at firſt what ſolution of iron gives the moſt beautiful black to galled cotton; afterwards he combined different ſolutions; he tried the ſolidity of the blacks he produced; he made the ſame trials with other metals and ſemi-metals upon galled cotton; he employed a great number of aſtringents in the ſame manner, and he ſubjected to trial cottons which had been prepared in

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* Mémoire ſur la Teinture en noir, qui a remporté le prix de la ſociété litéraire de Bruxelles en 1771. Rotterdam, 1777.

in different ways. We ſhall find, in the ſection of the ſecond part which treats of dying black, the proceſſes to which theſe repeated experiments have given riſe.

Of twenty-one kinds of aſtringents compared with galls, the ſaw-duſt of oak, the galls of this country, and the myrobalan citrons, are the only ſubſtances that produce a beautiful black, but which is ſtill neither ſo beautiful nor ſo ſolid as that produced by common galls. He found that the ſaw-duſt of oak is preferable to the bark which is employed by the dyers of thread, and he remarks that it is cheaper.

M. M. Lavoiſier, Vandermonde, Fourcroy, and myſelf, have been engaged in making experiments upon different aſtringents, in order to draw up a report which the academy entruſted to us. The ſubſtances upon which we judged it proper to make comparative trials were galls, oak bark, the raſpings of oak, taken from the interior part of the wood, the raſpings of the inner bark of the oak, logwood and ſumach. To determine the proportion of the aſtringent principle contained in theſe ſubſtances, we took ſucceſſively two ounces of each, and boiled them for half an hour, in three pounds of water; after the firſt, we uſed a ſecond water, which underwent a ſimilar boiling, and we continued theſe operations until the ſubſtances appeared to be exhauſted; we mixed the decoctions together that we had ſucceſſively obtained; we employed a very clear ſolution of ſulphate of iron, in which we knew exactly the proportion of the water and the ſulphate; we eſtimated, at firſt, the quantity of the aſtringent principle by the quantity of the ſulphate that each liquor decompoſed, and afterwards by the weight of the black precipitate that was formed. In order to ſtop at the preciſe point of ſaturation, it is neceſſary to carry on the precipitation very ſlowly, by pouring in the ſolution of ſulphate towards the end only drop by drop, and by ſtopping directly, when a new addition of this ſubſtance does not increaſe the intenſity of the black colour. When the liquor is too opake, ſo that we cannot diſtinguiſh the ſhade of the colour, we dilute a ſmall portion of it with a great quantity of water, and by adding a little of the ſolution of the ſulphate of iron in the end of a glaſs tube, we ſhall be able to know if it has reached the point of ſaturation; if we wiſh to preſerve the precipitate that is formed, it is neceſſary to dilute the liquor largely with water.

This operation deſerves attention, becauſe it affords an eaſy and accurate method of determining, in the workſhops, the proper proportions of aſtringents and of ſolutions of iron.

Three drachms 61 grains of galls were neceſſary to ſaturate the decoction of 2 ounces of galls; the precipitate collected and dried weighed 7 drachms 24 grains.

The decoction of oak bark is of a deep yellow colour; a very ſmall quantity of ſulphate of iron gives it a dirty red colour: a farther addition changes it to a black brown. The quantity of ſulphate neceſſary to ſaturate the decoction of 2 ounces of this bark was 18 grains; the precipitate, conſiſting of larger particles, which were more difficult to divide, when collected and dried weighed 22 grains; the liber, or inner bark of the oak, preſents nearly the ſame reſults.

The decoction of the ſaw-duſt of the heart of the oak requires, for its ſaturation, 1 drachm and 24 grains; the precipitate was preciſely of the ſame weight; the decoction of the inner bark of the oak affords very little precipitate.

The decoction of ſumach aſſumes a red violet colour, when we add to it a ſmall quantity of the ſolution of the ſulphate of iron. The quantity neceſſary for its ſaturation was 2 drachms and 18 grains. An accident prevented us from aſcertaining the weight of the precipitate; it reſembled perfectly that afforded by galls.

The decoction of logwood receives a ſapphire blue colour from the addition of the ſulphate of iron. If we exceed the point of ſaturation, the blue becomes of a dirty greeniſh colour. The quantity neceſſary for complete ſaturation was found to be 1 drachm 48 grains, and the weight of the precipitate was 2 drachms 12 grains. All the precipitates of the oak are formed readily; that of logwood with a little more difficulty, but ſtill with more facility than that of galls.

We afterwards found by trials made upon woollen ſtuff, that the quantity of aſtringents neceſſary to produce a black colour equally deep, on equal weights of the ſame ſtuff, are proportional to the quantity of the aſtringent principle in each ſubſtance, which we had aſcertained by the foregoing experiments: but the black obtained from the different parts of the oak did not ſtand boiling nearly ſo well as that produced by galls.

It does not appear that logwood alone can produce a black ſo deep as galls, or oak; and, beſides, the colour that it produces does not ſtand boiling ſo well as the one obtained from galls.

We read in the memoirs of Stockholm, for the year 1763, that the uva urſi gathered in Autumn, and dried with care, in order that its leaves may remain green, may be uſed as a ſubſtitute for galls.

The theory which I have given with regard to aſtringents is far from being complete in all its different parts; but it eſtabliſhes principles, the application of which may afterwards be made by experiments, that ought to be much more varied and more accurately performed than any that have hitherto been attempted. It will be neceſſary to confine ourſelves to the principal aſtringents only, becauſe the greater number of vegetables poſſeſs more or leſs of an aſtringent property, as may be ſeen from the trials of Bergius * and M. Durande †.

After having conſidered the aſtringent principle in its relations with the ſolutions of iron, it remains to conſider it with regard to the property which it has of combining with vegetable and animal ſubſtances, particularly the latter. Silk acquires by galling ‡, which conſiſts in macerating a ſtuff in a decoction of galls, a weight that cannot be taken from it by repeated

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* Materia medica e regno vegetabili.

† Mém. ſur les parties aſtringentes indigenes. Acad. de Dijon 1783.

‡ I ſhall apply the word *galling* to denote the combination of an aſtringent with a ſtuff, of whatever nature either of them may be.

peated waſhings: or, at leaſt, that can only be diminiſhed to a certain degree: after this operation, the ſtuff, immerſed into a ſolution of iron, is dyed black; becauſe the aſtringent principle, by decompoſing the ſulphate of iron, forms a triple combination with the oxid of the iron and the ſtuff.

A ſtuff that has been galled may combine with other colouring particles, in conſequence of which their colours will acquire ſolidity if they have it not of themſelves; ſo that the aſtringent communicates its own fixedneſs to the triple combination, and ſometimes to a more compound one that is formed, and commonly the colour becomes deeper by this combination.

By combining with animal ſubſtances, the aſtringent principle ſecures them from corruption, and tends to contract the texture of their parts; it is in this that tanning, the baſis of the preparation of leather conſiſts.

The prize which the Academy of Sciences has propoſed, with regard to this important art, will certainly procure more extenſive information, and ſerve to promote the progreſs of the art: but I hope the conjectures I have formed will not be altogether uſeleſs to thoſe who ſhall turn their attention to this ſubject.

An ounce of galls, diſtilled with a ſtrong heat, affords 3 drachms of carbon; an ounce of ſugar, 2 drachms 12 grains; an ounce of the colouring particles of thread, 2 drachms 24 grains; an ounce of plumb-tree well dried, 1 drachm 48 grains; an ounce of dry walnut-tree, alſo 1 drachm 48 grains: ſo that galls afford almoſt double the quantity of carbon that hard and dry wood does. I have elſewhere remarked *, that when the infuſion of galls, and that of ſumach, are decompoſed by means of the oxigenated muriatic acid, a copious precipitate of carbon is formed, particularly in the former.

From theſe obſervations, I conſider the ſuperabundance of carbon as the eſſential characteriſtic of the aſtringent principle: the hydrogen, which exiſts only in a ſmall quantity, has a ſtrong tendency to combine in part with oxigen: from this it happens, that when we allow the infuſion of galls to remain in contact with vital air, only a ſmall abſorption of vital air takes place, although the colour of the infuſion becomes much deeper: for in conformity with the theory I have delivered in the third chapter, and particularly in the *Annales de Chymie*, the carbon, by means of this ſlight combuſtion, becomes the prevailing ingredient, and the colour deepens and becomes brown.

A ſubſtance which contains a great quantity of carbon, and which can undergo only a ſlight degree of combuſtion, ſhould be of a very fixed nature, becauſe carbon does not combine with oxigen in the ordinary temperature of the atmoſphere, unleſs this combination be aſſiſted by other affinities, and becauſe ſlight changes in the temperature do not produce any in the dimenſions of the carbon: on the contrary, ſubſtances which contain much hydrogen, and in which the particles of the hydrogen are very much divided, ought to be eaſily decompoſed by the combination of the

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* Ann. de Chym. tom. VI.

the hydrogen with azote, or with oxigen. The ſeparation of their particles ought to be produced by ſmall changes in the temperature, becauſe the hydrogen is dilatable by heat, while the carbonaceous particles are not. It is in this manner, according to the ingenious remark of M. Monge, that a very fuſible metal, mixed with a metal that is much leſs ſo, renders the latter brittle in a degree of heat, which, by fuſing the former, deſtroys the continuity of the particles of the mixture.

When, therefore, the aſtringent principle is combined with an animal ſubſtance, it communicates to it the properties which it derives from carbon; the animal ſubſtance becomes leſs eaſily altered by ſlight changes in the temperature; inſtead of becoming putrid, it undergoes a ſlight combuſtion by the action of air: for, in all likelihood, tanning could not be performed in a veſſel cloſely ſhut: the effect of this combuſtion is the contraction of the particles of the ſubject, and this tends afterwards to preſerve it from putrefaction. The preliminary operations of tanning conſiſt chiefly in extracting all the fatty parts which are diffuſed in the cellular texture of ſkins, ſo as to allow the aſtringent principle, and even the air, to penetrate through them.

When I examine the analyſis that has been made of indigo, which may be conſidered as the leaſt changeable of all known colouring bodies, I obſerve, that this ſubſtance affords by diſtillation a greater proportion of carbon than galls themſelves. I omit in theſe calculations the carbon which enters into the compoſition of the thick oil that we principally obtain

tain from indigo, and that which is diſengaged under the form of carbonic acid, and of carbonated hydrogenous gas.

It appears to me, that we muſt alſo attribute the fixity of the colour of indigo to this ſuperabundance of carbon, and that the different proportion of this principle, is the chief cauſe of the difference obſerved in the fixity of colours; but the force of adheſion may alſo have much influence; for a principle that unites intimately with any ſubſtance, ought to form a more laſting combination than another principle which is more feebly diſpoſed to unite with it; but the aſtringent principle poſſeſſes this tendency to combine intimately in a very high degree, particularly with animal ſubſtances. I ſhall explain, by the ſame principles, the fixity that is communicated to the colouring particles by alumine, and thoſe metallic oxids which are not ſubject to variations in the quantities of oxigen they contain, ſuch as the oxid of tin.

All colouring ſubſtances which can combine with metallic oxids exert upon them an action analogous to that of aſtringents. Oxids are by this means more or leſs deprived of their oxigen, according to the force with which they retain it; the ſtrength of the affinity by which the colouring particles tend to combine with them; the proportion in which they meet, and the greater or leſs diſpoſition the colouring particles have to undergo combuſtion.

The colouring particles, on their part, undergo a change in their nature proportional to theſe circumſtances; thus the ſolutions of iron change all colours to a brown, into which the oxid of iron can enter, although it has only a green or yellow colour in the ſtate in which it is kept in ſolution by acids; and this effect goes on increaſing to a certain point; but the alteration of the colouring particles may afterwards be carried to a degree at which their colour is deſtroyed, and their tendency to combination diminiſhed; the oxid of iron is then brought back to a yellow, by the oxigen which it attracts and retains.

The mutual action of colouring particles, and of metallic oxids, explains the changes that are obſerved in the ſolutions of the colouring particles when mixed with metallic ſolutions. The effect produced is gradual, as I have already obſerved with regard to yellow wood.

Sometimes the mixture is not diſturbed at firſt; it loſes its tranſparency by degrees; precipitation begins; a depoſition is formed; and its colour becomes deeper and deeper. Light has conſiderable influence in producing theſe effects.

CHAP. VI.

Recapitulation of the theory delivered in this ſection.

IT is neceſſary to diſtinguiſh metallic colours from thoſe which belong to vegetable and animal ſubſtances.

The colours of metals are modified and changed by oxidation, according to the proportion of oxigen that is combined with them.

Vegetable and animal ſubſtances may poſſeſs of themſelves a particular colour, varying in the different ſtates through which they paſs, or they may owe their colours to colouring particles, which are either combined or ſimply mixed with them. There are particles of this kind, extracted from a variety of ſubſtances, which undergo different preparations, in order to ſerve the purpoſes of dying.

Colouring particles have chemical properties which diſtinguiſh them from all other ſubſtances; the affinities they have with acids, alkalies, earths, metallic oxids, oxigen, wool, ſilk, cotton, and thread, conſtitute the moſt important part of theſe properties.

In proportion to the affinity which the colouring particles have with wool, ſilk, cotton, and thread, they combine more or leſs readily, and more or leſs intimately, with each of theſe ſubſtances; and from this ariſes a primary difference in the proceſſes we employ occaſioned by the nature of the ſtuff, and that of the colouring ſubſtance.

By the affinity that the colouring particles have for alumine, and the metallic oxids, they form with theſe ſubſtances a combination, in which their colour is more or leſs modified, and becomes more fixed, and leſs eaſily affected by external agents, than formerly. This combination, being formed of principles which ſeparately poſſeſs a diſpoſition to unite with vegetable, and principally with animal ſubſtances, retains this property; it forms a triple combination with the ſtuff, and the colour which has been again modified in conſequence of this triple union, acquires a greater degree of fixity, and a greater power of reſiſting external agents.

The colouring particles frequently have ſuch an affinity for the alumine and metallic oxids, as to ſeparate them from acids which kept them in ſolution, and form with them a precipitate; but ſometimes the affinity of the ſtuff is neceſſary to effectuate this ſeparation.

The metallic oxids which combine with the colouring particles not only modify their colours by their own peculiar colour, but alſo act upon their compoſition by the oxigen they contain. The change that the colouring particles undergo by this means is ſimilar to that which they ſuffer from the air, by which all colours are more or leſs injured.

Of the two principles which form atmoſpheric air, it is only the vital air, or oxigenous gas, that acts upon the colouring particles; it combines with them, and then weakens their colour and renders it pale: but its action is ſoon exerted, chiefly upon the hydrogen, which enters into their compoſition, and with it forms water. This effect muſt be conſidered as a true combuſtion. By it the carbon, which enters into the compoſition of the colouring particles, becomes prevalent; and the colour paſſes generally to a yellow, to a fawn, to a brown; or this degradation, by mixing with what remains of the firſt colour, produces other appearances.

Light promotes the combuſtion of the colouring particles, which frequently cannot be performed without its aſſiſtance; and it is in this way that it contributes to deſtroy colours. Heat alſo favours it, but leſs effectually than light, till raiſed to a certain degree.

It is on a ſimilar combuſtion that the effects of the nitric, the oxigenated muriatic, and ſulphuric acids depend, when they change the colour of the ſubſtances upon which they act from a yellow to a black *.

The effects of combuſtion may be concealed by the oxigen combining with the colouring particles, without exerting its action in a particular manner upon the hydrogen.

Colours are more or leſs ſolid, and more or leſs fixed, according to the greater or leſs tendency that the colouring particles have to undergo this combuſtion, and that in a greater or leſs degree.

There are ſome ſubſtances which may act as ſolvents on the colours of ſtuffs, in conſequence of their ſuperior

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* There are a great number of other natural phenomena, beſides thoſe I have already mentioned (Ann. de Chem. T. VI.) in which the formation of water appears to me to be undeniable; thus the bitter taſte of unripe fruits is probably owing to oxigen feebly combined; but during maturation, the fruit which was hard becomes ſoft; water is formed; the juice becomes ſaccharine and copious: but ſugar contains a large portion of carbon. When the fruits are too ripe, and ſuffer the degeneration that is natural to them, their colour indicates the ſuperabundance of carbon. It appears from the experiments of the celebrated Ingenhouſz (Exper. ſur les vege, T. II.) that combuſtion takes place on the ſurface of fruits expoſed to the ſun, to ſuch a degree as to produce carbonic acid.

Dung, either alone or mixed with ſtraw or chaff, is converted into mould by a combuſtion that is even accompanied with conſiderable heat, ſo that the carbon becomes ſuperabundant in the latter. On this depend perhaps many of the phenomena of vegetation.

rior affinity: of this kind are acids, alkalies, and ſoap; however, a ſmall part of theſe agents may ſometimes be ſuperadded to the ſtuff, and in that way alter its colour.

Metallic oxids produce in the colouring particles with which they unite a combuſtion proportional to the quantity of oxigen which can be taken from them by theſe particles.

The colours that the combinations of the metallic oxids with the colouring particles aſſume, are then the conjoined effect of the colour belonging to the colouring particles, and of that of the metallic oxid; but it is neceſſary to conſider the colouring particles and the metallic oxids in the ſtate to which the diminution of oxigen reduces the latter, and the diminution of hydrogen the former.

It follows from this, 1. That metallic oxids, to which the oxigen adheres very weakly, are not fit to be employed as intermediate ſubſtances to the colouring particles, becauſe they would produce too great a degree of combuſtion; ſuch are the oxids of ſilver, gold, and mercury.

2. That oxids which undergo conſiderable changes in their colour, by parting with a greater or leſs quantity of oxigen, are alſo unfit for intermediate ſubſtances, eſpecially for clear ſhades, becauſe they produce changeable colours; ſuch are the oxids of copper, lead, and biſmuth.

3. That the oxids which have a ſtrong affinity for their oxigen, and which ſuffer little change of colour by the loſs of a portion of it, are the fitteſt for this purpoſe; ſuch in particular is the oxid of tin, that

readily quits its ſolvent, that has a ſtrong affinity with the colouring particles, and affords them a very white baſe, and one proper to give brightneſs to their ſhades, without altering them by the mixture of any other colour. The oxid of zinc poſſeſſes in part theſe properties.

To account for the colours reſulting from the combination of the colouring particles with the baſe that a *mordant* affords them, it is likewiſe neceſſary, to attend to the proportion in which the colouring particles unite with this baſe: thus the ſolution of tin, which forms a very copious precipitate with a ſolution of colouring particles, and by this ſhows that the oxid of tin enters in a large proportion into the precipitate, has much greater influence by the whiteneſs of the baſe upon the colour of the precipitate than the ſolution of zinc, or that of alum, which generally form a much leſs conſiderable quantity of precipitate. The precipitates produced by theſe two laſt ſubſtances retain nearly the natural colour of the colouring particles.

It is neceſſary, therefore, in the action of *mordants*, to diſtinguiſh the combinations which may be formed by their means between the colouring particles, the ſtuff, and the intermediate ſubſtance, the proportions of the colouring and intermediate ſubſtances, the modifications of colour that may take place from the mixture of the colour of the colouring particles, and of the baſe to which they are united, and, laſtly, the changes that the colouring particles may undergo from the combuſtion which may be produced by the intermediate ſubſtance.

Aſtringents do not owe their diſtinguiſhing quality to an acid, or to any other identical principle; but to the property which they poſſeſs, of combining with the oxid of iron, of bringing it back to the ſtate of a black oxid, and of aſſuming themſelves a brown colour from the combuſtion which they by this means undergo.

Galls, which we ought to conſider as the repreſentatives of the claſs of aſtringents, readily undergo a ſlight combuſtion, that gives them a deep brown colour; but this combuſtion, which requires only a ſmall quantity of oxigen, is ſpeedily ſtopt without affecting their properties.

Theſe ſubſtances owe their durability to the great quantity of carbon they contain; and as they poſſeſs the property of combining with ſome vegetable ſubſtances, with many colouring particles, and eſpecially with animal matters, they ſerve as an intermediate ſubſtance between them, and communicate to them their own durability.

SECTION SECOND.

ON THE OPERATIONS OF DYING IN GENERAL.

CHAP I.

Of the diſtinguiſhing characters of wool, ſilk, cotton, and flax, and of the operations by which they are prepared for dying.

ARTICLE I.

Obſervations on the difference between animal and vegetable ſubſtances.

I DARE not flatter myſelf with the hope of explaining many of the properties which depend on the compoſition of organized matter; but the knowledge we have already acquired, with regard to the compoſition of vegetable and animal ſubſtances, will enable us, in ſome degree, to diſcover the cauſe of the different tendencies that wool, ſilk, cotton, and flax have to unite with the colouring particles, or with the baſes which *mordants* afford.

Wool and ſilk belong to the claſs of animal; cotton, flax, and hemp, to that of vegetable ſubſtances.

The principal diſtinguiſhing character in the compoſition of vegetable and animal ſubſtances is, 1. Animal ſubſtances contain a great quantity of a peculiar principle, *azote*, which in the elaſtic ſtate forms what is called *phlogiſticated gas*, or *phlogiſticated air*. This is found only in very ſmall quantity in vegetables:

2. Animal ſubſtances contain a greater quantity of hydrogen or the baſe of inflammable gas.

The differences that are obſerved in the diſtillation of animal and vegetable ſubſtances, ariſe from theſe two cauſes: the former afford a great quantity of ammoniac, which is a compound of azote and hydrogen; the latter afford only a ſmall quantity, and in general give rather an acid. The former afford a great quantity of oil, the prevailing ingredient of which is hydrogen: this oil, at a temperature ſomewhat high is ſtrongly diſpoſed to ſeparate, and to be evaporated; the latter ſometimes do not afford the ſmalleſt quantity. In conſequence of this compoſition, animal ſubſtances produce at the commencement of their combuſtion, a very bright flame, but this is quickly ſuffocated by the carbon that is formed, and which poſſeſſes peculiar characters. Their combuſtion is accompanied by a penetrating odour, owing to the ammoniac and oil that are formed, and eſcape the inflammation; they are ſubject to putrefaction, during which, ammoniac is evolved, as in diſtillation, by the more intimate union of the azote and hydrogen; while, on the contrary, vegetables undergo only a ſpirituous or an acid fermentation. In this place, I merely allude to opinions that I have explained at full length in ſome other memoirs.

The particles of animal ſubſtances, containing a number of principles diſpoſed to aſſume the elaſtic ſtate, adhere leſs ſtrongly among themſelves, than thoſe of vegetables, and are more diſpoſed to combine with other ſubſtances.

On this account, they are more liable to be deſtroyed by different agents, and more diſpoſed to combine with the colouring particles.

Thus the fixed alkalies, either pure or cauſtic, deſtroy animal ſubſtances, becauſe they combine with them; in conſequence of which, they become ſaturated and loſe their cauſticity *.

From this action of alkalies on animal ſubſtances, it happens, that they cannot bear the action of leys, and that alkalies ought to be employed with great caution in the proceſſes of dying, while, on the contrary, no dread can be entertained reſpecting the uſe of alkalies for vegetable ſubſtances.

The nitric and ſulphuric acids have alſo a ſtrong action upon animal ſubſtances. The former decompoſes them, diſengages the azote, ſeparates the fat, and forms the carbonic and oxalic acids, with a part of the hydrogen, and a part of the carbon; the latter diſengages inflammable gas, probably alſo azotic gas, and reduces the other principles to a carbonaceous ſtate.

Silk appears to approach in ſome degree to vegetable ſubſtances, by a weaker tendency to unite with the colouring particles, and by a greater reſiſtance to the action of acids and alkalies, which may ariſe either from the ſame principle being more intimately combined in it than in wool, or more probably from the ſmaller quantity of azote and hydrogen it contains; but although the action that alkalies and acids exert

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* Mem. de l'Acad. 1783.

exert upon ſilk, be not ſo ſtrong as upon wool, it is nevertheleſs neceſſary to uſe them with great caution, becauſe the brightneſs of the colour we wiſh for in ſilk, appears to depend upon the ſmoothneſs of its ſurface, which muſt not be injured.

Cotton reſiſts the action of acids better than flax or hemp, and it is only with difficulty that we are able to deſtroy it by the nitric acid.

ARTICLE II.

Of Wool.

The principal differences of wool conſiſt in the length and fineneſs of its filaments. Wool which has very fine filaments is reſerved for the beſt ſuperfine cloth. The fineſt is brought from Spain; M. d'Aubenton has proved that we can obtain wool in France, not inferior to that from Spain, by making a careful ſelection of rams, and by confining the ſheep in parks through the whole year. As the ſight alone is apt to deceive us with regard to the fineneſs of wool, and as it is of conſequence to manufacturers to know it with accuracy, he has given a method of determining it with the neceſſary preciſion, by uſing a micrometer, in order to compare with the microſcope, the fineneſs of the wools we wiſh to examine, with that which we chooſe as a term of compariſon *.

Although long wool be not ſo fine as Spaniſh wool, and therefore cannot be employed for ſuperfine cloths, it is, however, very uſeful for the woolen ſtuffs known by the name of Engliſh cloths; and as the ſheep which afford it have by far the ſtrongeſt fleeces, the advantages obtained are not inferior to thoſe from the fine wool; beſides, the cloths that are formed of their wool are cheaper, and have a more extenſive ſale; the Engliſh owe the proſperity of their commerce in part to the abundance of this wool. But the breed of ſheep that afford the one or the other kind of wool, depends in ſome meaſure on the nature of the paſturage, a circumſtance that ought to make us careful in the choice of it.

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* Mem. de l'acad. 1779. Inſtructions pour les bergers & pour les propriétaires de troupeaux.

It is of ſo great conſequence to our manufactures to multiply our flocks, and to improve our wool, that no opportunity of calling the attention of the public to this object ſhould be loſt.

Wool is naturally covered with a kind of greaſe that is called the *ſweat*. This coating preſerves it from moths, ſo that wool is only ſcoured when it is to be dyed or ſpun.

To ſcour wool, it is put for a quarter of an hour into a copper, containing a ſufficient quantity of water mixed with a fourth part of putrid urine heated till the hand can juſt bear it, and ſtirred from time to time with a ſtick; it is then taken out and drained; after this it is put into a large baſket, placed in running water, and ſtirred till the greaſe is entirely waſhed out, and renders the water no longer milky; it is then taken out again and drained. It ſometimes loſes during this operation more than a fifth of its weight. It is of importance that the ſcouring be performed with care, becauſe by means of it the wool is more diſpoſed to take on the dye.

The ammoniac, or the volatile alkali, which is formed in putrid urine, combines with the greaſe, and forms a ſoap with it, by which it is rendered ſoluble in water.

Wool is dyed in the fleece, or without being ſpun, eſpecially when it is intended to be formed into cloths of mixt colours; or it may be dyed after it is ſpun, and it is then chiefly intended for tapeſtry; but it is moſt commonly dyed in the form of cloth.

When wool is dyed in the fleece, its ſeparated filaments abſorb a greater quantity of colouring particles than when it is ſpun; for the ſame reaſon, ſpun wool takes up more than cloth; but cloths vary much in this reſpect, according to their degree of fineneſs, and their looſer or cloſer texture; beſides, the difference of their dimenſions, the changeable qualities of the ingredients uſed in dying, and the different circumſtances of operations, prevent us from truſting to the preciſe quantities recommended in the proceſſes that are deſcribed.

This conſideration ought to be extended to all dyes.

For the greater part of colours wool requires to be boiled in a vat with ſaline ſubſtances, principally with alum and tartar; this is what we call *bouillon*, and which we will have an opportunity to deſcribe in various proceſſes; but there are dyes for which wool does not require theſe preparations; it is then neceſſary to wet it with lukewarm water, and afterwards to expreſs it or allow it to drain. This precaution is generally neceſſary with all thoſe ſubſtances we mean to dye, in order that the colour may be more eaſily introduced, and more equally diſtributed.

M. Monge has explained the proceſs of felt-making, and the effects of fulling, from the external conformation of the wool and hair of animals. He has made a number of curious obſervations on this ſubject, the principal of which I ſhall relate in his own words:

" We can diſcover nothing peculiar in the ſurface " of fibres of the wool and hair of animals; how" ever, the ſurfaces of theſe objects are not ſmooth, " they muſt be formed, either of plates laid upon one " another from the root to the point, almoſt in the ſame " manner as the ſcales of fiſhes reſt upon one another " from the head to the tail; or, perhaps, rather of " zones placed above one another, as is obſerved in " horns.

" If we take a hair by the root in one hand, and " make it ſlide between two fingers of the other, from " the root towards the point, we feel almoſt no fric" tion or reſiſtance, and we hear no noiſe; but if, in " laying hold of it by the point, we make it paſs in " the ſame manner between the fingers of the other " hand, from the point towards the root, we feel a reſiſt" ance that did not occur in the former caſe; a tremu" lous motion is produced perceptible to the touch, " and alſo manifeſted by a ſenſible noiſe.

" We have already ſeen, that the texture of the " ſurface of a hair is not the ſame from the root to the " point as from the point towards the root; and that " a hair, when it is preſſed between the fingers, " finds greater reſiſtance in ſliding, and taking a pro" greſſive motion towards the point, than in taking the

“ ſame motion towards the root; but as this tex-
“ ture is the principal object of the preſent memoir, it
“ may be neceſſary to prove it ſtill farther by ſome
“ other obſervations.

“ If, after having laid hold of a hair between the
“ thumb and forefinger, we make theſe ſlide alternate-
“ ly upon one another in the direction of the length
“ of the hair, the hair takes a progreſſive motion in
“ that direction, and its motion is always directed to-
“ wards the root. This effect is not connected, ei-
“ ther with the nature or texture of the ſkin of the fin-
“ gers; for if we turn the hair ſo that the point may be
“ in the place of the root, the motion takes place in a
“ contrary direction; that is to ſay, the motion is al-
“ ways directed towards the root.

“ Theſe remarks, to which M. Monge has added
“ many others, are all made upon a human hair taken
“ as an example; but they are equally true when ap-
“ plied to horſes hair, to the fibres of wool, and, in ge-
“ neral, to the hairs of all animals. The ſurface of
“ all theſe objects is formed of rigid plates, placed a-
“ bove one another in the form of tiles, from the root
“ to the point, which allow progreſſive motion towards
“ the root, and oppoſe a ſimilar motion towards the
“ point.

“ It is this conformation which is the principal cauſe
“ of the aptneſs for felt-making, that the hairs of all
“ animals poſſeſs.

“ In ſhort, the hatter, by ſtriking the flocks of wool
“ with the cord of his bow, detaches and ſeparates each
“ fibre in particular; theſe fibres fall back upon one
“ another in every direction on the table, where they

"form a layer of a certain thickneſs; the workman "then covers them with a piece of cloth, which he "preſſes with open hands, moving the hands in different directions. The preſſure brings the fibres of "the wool together, and increaſes the points of contact. The agitation gives to each of them a progreſſive motion towards the root; by means of this "motion the fibres are interwoven with one another, "and the plates of each fibre, by catching thoſe of "other fibres that lie in a contrary direction, keep "the whole in the compact texture which the preſſure "has made it aſſume. In proportion as the texture becomes compact, the preſſure of the hands ought to "be increaſed, both to render it more compact, as "well as to ſupport the progreſſive motion of the fibres and their interlacement, which find then a "greater reſiſtance; but in the whole of this operation the fibres of the wool lay hold only of one "another, and not of the cloth, the fibres of which, "as has been already obſerved, are ſmooth, and do "not afford the ſame opportunity.

"The ſtructure of the ſurface of the fibres of wool, "and the hairs of animals, does not alone conſtitute "their aptitude for felt-making; it is not ſufficient "that each fibre can aſſume a progreſſive motion towards the root, nor that the inclined plates, by laying hold of one another, preſerve the texture in the "ſtate produced by preſſure: it is alſo neceſſary that "the fibres be not ſtraight like needles; by means of "agitation each of them would continue its progreſſive motion without changing its direction, and the "effect of the operation would be the ſeparation of

" the whole from the centre, without producing any " interlacement. It is neceſſary then, that each fibre " be curled, that the extremity which is next the " root be diſpoſed to change its direction perpetually, " to warp itſelf around new fibres, and to return upon itſelf, if determined by any change in the poſition " of the other parts of its body. It is becauſe the " wool is naturally formed in this manner that it is " ſo proper for felt-making, and that it can be employed without any neceſſity of making it undergo any previous preparation.

" But the hairs of the rabbit, the hare, and the " beaver, are naturally ſtraight; they cannot be employed for felt-making, without having undergone a preliminary operation, which conſiſts in rubbing them, before taking them off the ſkin, with a " bruſh impregnated with a ſolution of mercury in " the nitric acid. This ſolution, by acting only upon " one ſide of the hairs, changes their direction from " a ſtraight line, and gives to them the aptneſs to " felt-making which wool naturally poſſeſſes.

" The operation of fulling woolen ſtuffs has ſo " great a relation with felt-making, that I believe " it will be neceſſary here to enter into ſome details " on the ſubject.

" The aſperities on the ſurface of the fibres of wool, " and their tendency to take a progreſſive motion towards the root, is an obſtacle to the ſpinning of " wool and the making of ſtuffs. In order to ſpin " wool, it is neceſſary to teaze it, and afterwards to " cover all the fibres with a layer of oil, which by "filling the cavities renders the aſperities leſs perceptible, in the ſame manner as we put a layer of oil on a ſmooth file to render it ſtill ſmoother. When the piece of ſtuff is made, it is neceſſary to cleanſe it from this oil, which gives it a diſagreeable ſmell, and might prevent it from taking on the dye we wiſh to give it: for this purpoſe, they are carried to the fulling machine, where they are beat with mallets in a trough full of water mixed with a quantity of clay. The clay combines with the oil, and renders it ſoluble in water; the whole is made to paſs through freſh water brought to it by the machine itſelf, and after a certain time the ſtuff is ſcoured.

"But ſcouring is not the only object of fulling; the alternate preſſure that the mallets exert upon the piece of ſtuff, eſpecially when the ſcouring is far advanced, produces an effect analogous to that occaſioned by the hands of the hatter; the fibres of wool, which compoſe one of the threads of the warp or woof, take a progreſſive motion, and inſinuate themſelves into the contiguous threads, then into thoſe which follow; and, in a ſhort time, all the threads of the warp, as well as of the woof, are felted together. The ſtuff, after having undergone a contraction in all its dimenſions, partakes both of the nature of a web, and that of a felt. We can cut it without its ſeparating into threads, and it is not neceſſary to hem the different pieces of which a garment is formed. If it is an ordinary knitting of wool, the ſtitch is no longer diſpoſed to run when it happens to break: in ſhort, the threads of the warp and woof being neither ſo diſ-

" tinct nor ſeparated in ſo eaſy a manner, the ſtuff be-
" comes thicker, and forms warmer cloathing."

ARTICLE III.

Of Silk.

Silk is naturally varniſhed by a kind of ſubſtance which we conſider as a gum, and to which it owes its ſtiffneſs and elaſticity. That which is moſt common in our country, contains, beſides this, a yellow colouring matter.

The greater number of uſes for which ſilk is intended, require not only that it be deprived of its colouring matter, but alſo of its gum. We obtain both purpoſes by means of ſoap, and we give the name of dreſſing *(decreuſage,)* to the operation by which we give to ſilk its whiteneſs and its flexibility.

The dreſſing ſhould not be ſo complete for ſilks that are to be dyed as for thoſe that are to be made white; and it even ought to differ according to the colour which the ſilks are to receive. This difference conſiſts chiefly in the proportion of ſoap that is employed; thus for ordinary colours we boil the ſilk for three or four hours, in a ſolution of twenty pounds of ſoap to the hundred weight of ſilk, taking care to fill the copper from time to time with water, ſo as to have it always in ſufficient quantity. We increaſe the quantity of ſoap for ſilks that are to be dyed blue, and eſpecially for thoſe that are to be dyed of a poppy or cherry colour, &c. becauſe a whiter baſe is required for theſe than for leſs delicate colours.

In treating of each particular colour, I ſhall mention the quantity of ſoap proper for the ſilk that is to receive it.

When ſilk is to be uſed white, it is made to undergo three operations; the firſt is called Ungumming: it conſiſts in keeping hanks of ſilk in a ſolution of thirty pounds of ſoap to the hundred weight of ſilk; this ſolution ſhould be made very warm, but not ſo as to boil. When that part of the hank which is in the liquor is completely deprived of its gum, which is known from its whiteneſs and flexibility, we turn the hanks upon the rods, in order to make the part that had not been immerſed undergo the ſame operation; and we take the hanks out of the vat, wringing them on pegs in proportion as the ungumming is performed.

The ſecond operation is called Boiling; the ſilks are ſhut up in bags of coarſe cloth, from twenty-five to thirty pounds of ſilk in each bag, which is termed a pocket: a ſoap vat is prepared, ſimilar to the firſt, only diminiſhing the quantity of ſoap, and it is made to boil for an hour and an half, taking care to move the bags one over another, to prevent thoſe at the bottom of the copper from undergoing too great a degree of heat.

The third operation is called Whitening: this operation is chiefly intended to give a ſlight ſhade to ſilk, which renders the white more agreeable, and by means of which it obtains different names. Thus we make a diſtinction between china white, ſilver white, azure white, and thread or milk white. A ſolution of ſoap is made, ſo that by beating it with a ſtick, a froth is produced, that enables us to judge whether it be of the proper ſtrength; and for china white, which ought to have a reddiſh hue, we add a little arnotto, and keep the ſilk there till it acquires the ſhade deſired. We give to other whites a tinge more or leſs blue, by means of azure added to the ſolution of ſoap; but we had previouſly put in ſome of it in the boiling.

To prepare azure, we take fine indigo, and after having waſhed it two or three times in water moderately warm, we pound it in a mortar, and pour boiling water upon it: we allow it to ſettle, and we uſe the liquor which retains only the moſt ſubtile parts: it is this we call Azure. We can ſubſtitute for it a ſmall quantity of the liquor of a new indigo vat.

At Lyons, where they produce a more ſhining white than at Paris, they uſe no ſoap for the third operation; but after the ſecond, they waſh the ſilks, ſulphur them, and add the azure in river water. In this method, it is of conſequence to uſe water that is very clear.

When ſilks are ſmooth, and have taken on the ſhade we deſire, they are wrung and dried.

The white obtained by the means we have deſcribed is not ſufficiently bright for ſilks intended for white ſtuffs; but it is alſo neceſſary to expoſe them to the vapour of ſulphur; this operation is deſcribed under the article SULPHUR.

As ſoap appears to injure the luſtre of ſilk, the academy of Lyons in the year 1761 propoſed, as the ſubject for a prize, to diſcover a method of dreſſing ſilks without ſoap, The prize was adjudged to M. Rigaut de St Quentin, who, inſtead of ſoap, propoſed to employ a ſolution of ſalt of ſoda, or carbonate of ſoda, diluted in a quantity of water ſufficient to prevent it from injuring the ſilk: but this method muſt have been found inconvenient, ſince it is not at all employed, although it be well known, and eaſily practiſed.

M. l'Abbé Collomb* has publiſhed a number of obſervations on the dreſſing of ſilk, by means of water alone, which merit particular attention. Having perceived that a ſkain of yellow ſilk, which he boiled for about three hours in common water, had loſt almoſt an eight of its weight, he repeated the boiling twice, and in this way reduced the weight almoſt a fourth.

Silk which has ſuffered this loſs of weight preſerves however a yellow colour, or rather the colour of chamoy leather, which prevents it from being uſed for ſtuffs that are to remain white, or to take on colours, the beauty of which depends on the whiteneſs of the baſe to which they are applied: but it aſſumes colours very well which its own tinge cannot injure; thus the black that it takes on is preferable to that of ſilk dreſſed with ſoap.

After this operation the ſilk remains very ſtrong and tough; threads of it, compared with ſimilar threads dreſſed with ſoap, are able to ſuſtain weights that break the latter.

It required eight hours boiling to diſſolve all the varniſh of the ſilk, and by this it loſt a little more than a fourth part of its weight; but the boiling ſhould be continued longer when the mercury in the barometer is low, becauſe the greater the weight of the atmoſphere, the higher is the degree of heat that the water aſſumes in boiling.

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* Obſervations ſur la diſſolution du vernis de la ſoie. Journ. de Phyſ. Aout 1785.

This conſideration led M. Collomb to try the boiling of ſilk in Papin's digeſter, and indeed it required only an hour and a quarter to produce a complete ſolution of the varniſh, although the degree of heat was inferior to that which ought to produce the effects obſerved by philoſophers in this kind of concentrated boiling.

I have ſeen a pattern piece of ſilk dreſſed by M. Collomb; it appeared to me to poſſeſs the qualities mentioned by that author, but it was leſs flexible and ſoft than ſilk dreſſed with ſoap.

M. le Camus, a learned naturaliſt of the Academy at Lyons, ſent me a ſmall quantity of the ſubſtance that is ſeparated from ſilk by means of water in the operation of M. Collumb: this ſubſtance was black, brittle, and ſhining in its fractures; it afforded by diſtillation the products of animal ſubſtances; it diſſolved very readily in hot water, and left very little reſiduum upon the filter; the ſolution, which was clear and of a greeniſh yellow colour, was not ſenſibly altered by acids or by alkalies.

The ſolution of alum produced a dirty white precipitate; that of the ſulphate of copper a black brown precipitate; that of the ſulphate of iron a brown precipitate; the nitro-muriatic ſolution of tin a white precipitate; the acetite of lead a brown precipitate.

All theſe precipitates were ſcanty, and more or leſs viſcid,

viſcid. The infuſion of galls and that of ſumach produced a white precipitate.

Alcohol did not diſſolve this ſubſtance, even by boiling, but only a yellow colouring matter. This ſolution afforded by evaporation a reſiduum in ſcales of an amber colour. I mixed ſome drops of the muriatic acid with nearly two ounces of alcohol that I had boiled, upon twenty grains of the gum of ſilk, a complete ſolution was produced; but this ſubſtance in cooling aſſumed the form of a jelly.

The ſubſtance that we ſeparate from the ſilk in dreſſing is therefore of an animal nature; it is for this reaſon that the ſoapy waters employed in the dreſſing, putrify quickly; when it is no longer retained by its affinity with the ſilk it diſſolves readily in water, but not in alcohol. Although it be not of a vegetable nature, we ſee the term Gum may be applied to it with great propriety. The yellow colouring part is ſoluble in alcohol. When this part is ſeparated, the gum becomes brown: it would appear that this colour is produced by the heat it undergoes in boiling, ſince, when we ſeparate only the yellow colouring part, according to the proceſs of M. Baumé, of which we ſhall afterwards ſpeak, the ſilk remains white.

In the proceſs of M. Collomb the gum is alſo ſeparated, and carries along with it only a part of the yellow colouring particles: but in the dreſſing with ſoap, both the gum and yellow colouring particles are ſeparated from the ſilk.

I boiled yellow ſilk in a retort, where the vapours being more cloſely confined than in the open air, ought to produce a degree of heat ſuperior to that of boiling in the open air: after four hours boiling, the ſilk had loſt nearly a fourth part of its weight, but it preſerved its colour almoſt entire. I boiled, in the ſame manner, a pattern in water impregnated with marine ſalt; it became whiter, but loſt leſs of its weight, although the degree of heat was certainly increaſed by the reſiſtance which the ſalt made to the evaporation: a part of the marine ſalt perhaps combined with the ſilk. Were we to try other ſalts, we might probably find ſome which, without injuring the ſilk, would produce a more ready ſolution of the gum and colouring part.

When ſilk is intended to be formed into blond lace and gauzes, it ought to preſerve the ſtiffneſs and elaſticity which are natural to it: the greater part of that produced in our climate has a yellow colour, and it is the white ſilk from China that is chiefly uſed for theſe purpoſes; but as it is obtained at a price which does not permit our manufactures to ſupport a rivalſhip with the Engliſh, through whoſe hands it comes to us, eſpecially as they retain the fineſt for their own manufactures, we have endeavoured to diſcover a method of depriving yellow ſilk of its colouring part without affecting its gum, and conſequently without depriving it of its elaſticity.

M. Baumé has reſolved this intereſting problem; but he has kept his proceſs ſecret: ſome artiſts, to whom he had communicated it, or directed by ſome hints, have ſucceeded in performing this proceſs: however, it appears to be ſubject to accidents, which increaſe the expence by the loſs they occaſion; ſo that it has not hitherto been generally employed, notwithſtanding the advantages that it holds out to our manufactures,

tures. We ſhall point out what has tranſpired to the public reſpecting this proceſs.

A ſmall quantity of the muriatic acid is mixed with alcohol, and the ſilk plunged into it. It is neceſſary that the muriatic acid be pure, and do not contain any nitric acid, becauſe this laſt would give the ſilk a yellow tinge. It appears that the moſt difficult part of the proceſs is to produce a white that is equal, eſpecially when we operate upon large quantities. It appears alſo, that we find great difficulty in drying white ſilk without its becoming wrinkled; for this reaſon it is proper to keep it extended while drying: the proceſs would be too expenſive, if we did not obtain the alcohol that is loaded with the colouring part, and make it ſerve for ſubſequent operations. It is neceſſary, therefore, to diſtill it with a gentle heat, in an earthen or glaſs veſſel.

It appears from the above-mentioned experiments, that the muriatic acid ſerves in this proceſs to ſoften the gum, ſo as to enable the alcohol to diſſolve the colouring part that is combined with it.

Aluming ought to be conſidered as one of the general operations of dying upon ſilk, becauſe without alum, the greater part of the colours we apply to ſilk would neither poſſeſs beauty nor ſolidity.

To perform this proceſs, we put into a caſk or tub about forty or fifty buckets of water, with forty or fifty pounds of Roman alum, which had previouſly been diſſolved in a copper full of water, ſufficiently warm; ſtirring carefully the mixture, in order to prevent the cryſtallization of the alum.

After having waſhed the ſilk by beetling it, and even by wringing it upon the pegs to extract the ſoap it may have retained, we plunge it into the alum vat, where it is allowed to remain nine hours; after which we wring it with the hand over the tub, and carry it to the river to waſh it.

We can make a hundred and fifty pounds of ſilk paſs through a vat like the preceding, without any neceſſity for adding any more alum; but when we perceive that the vat begins to weaken, which a little experience enables us to do by the taſte, we diſſolve twenty to twenty-five pounds of alum, which is put into the vat as formerly, and we continue to renew the vat in this manner, till it begins to emit a bad ſmell. We then endeavour to exhauſt it by paſſing the ſilks through it which are intended for dark colours, ſuch as browns, marones, &c. and we throw it away in order to make a new ſolution.

Silks are always alumed in the cold, for when they are alumed in a warm vat they are apt to loſe a part of their luſtre.

ARTICLE IV.

Of Cotton.

Cotton is the down, or ſoft hair, that is contained in the *ſeed-pod* of a tree or ſhrub which grows in warm countries. This down is ſeparated from the ſeeds by means of a kind of mill which it covers.

Climate has a great influence upon the qualities of cotton, and the different kinds of the cotton tree ſeem to agree well with heat*. But a great variety of cotton trees are to be found in the iſlands of America; and it appears from what M. Bennet † has ſtated, that the colonies have hitherto neglected to make a ſelection of thoſe which would be the moſt profitable, and in conſequence of this, they have loſt a great part of the advantages they might have obtained from this valuable production.

The principal differences of cotton conſiſt in the length of its filaments, their fineneſs, their ſolidity, and colour.

The colour of cotton varies from a deep yellow to a white; that of Siam and Bengal has the deepeſt colour, and it is often formed into ſtuffs which preſerve its natural colours. The moſt beautiful kinds are not the whiteſt, but it is neceſſary to whiten them by proceſſes ſimilar to thoſe by which we whiten thread, but fewer and leſs tedious operations are required for cotton than for thread. Inſtead of theſe operations, we may employ the oxigenated muriatic acid. Beſides ſaving time, we give it a more beautiful white than by the ordinary bleaching, and from the obſervations of M. Dècroiſille, the ſtuff appears more diſpoſed to take on the beautiful colours of dying. I have bleached with ſucceſs the yellow cottons of St Domingo, the ugly and tenacious colour of which renders it uſeleſs in commerce.

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* Eſſai ſur les caracteres qui diſtinguent les cotons des diverſes parties du monde, &c; par M. Quatremere Disjonval.

† Tranſactions of the ſociety inſtituted at London for the encouragement of arts, manufactures, and commerce, vol. 1.

In order to diſpoſe cotton thread to receive the dye, it is made to undergo an operation called *dreſſing.* Some boil it in ſour water, but moſt frequently an alkaline ley is employed; the cotton is boiled in this ley for two hours, after which it is wrung dry; it is then waſhed in the river till it renders the water no longer muddy, and is afterwards dried.

The cotton cloths intended for printing are ſteeped for ſome time in water, impregnated with about a fiftieth or more of the ſulphuric acid; after this, we waſh it carefully in running water, and dry it. I have obſerved that the acid uſed in this operation diſſolves the calcareous earth, and the iron, which may alter the colours of the cloth.

We may conſider aluming and galling as general operations in the dying of cotton and of thread, which ought to be employed for the greater number of colours.

Aluming ought to be performed in the proportion of four ounces of alum to each pound of the ſtuff; the alum is to be diſſolved with the precautions pointed out in the preceding article: to this a ſolution of ſoda is added, which may be eſtimated at a ſixteenth part of ſoda to one of alum; ſome add a ſmall quantity of tartar and arſenic. The thread is well impregnated with this ſolution, by working it pound by pound; after which, the remainder of the vat is poured upon thread heaped together in a veſſel, and it is alowed to remain there twenty-four hours: after the alluming, it is ſoaked in running water an hour and a half, or two hours, and then waſhed. I have found that cotton acquires about a fortieth of its weight during this operation.

Galling is performed with different proportions of galls, or other aſtringents, according to the qualities of the aſtringents, and according to the effects we wiſh to obtain.

We boil for two hours, powdered galls, in a quanty of water, that ſhould be proportioned to the quantity of thread that is to be galled; after this the vat is allowed to cool till we are able to bear the hand in it; we divide it into parts as equal as poſſible, in order that we may be able to work it pound by pound; and, as in aluming, we pour the remainder upon the whole cotton put together. We allow it to remain twenty-four hours, eſpecially when it is intended for a madder colour, or for black; but for other colours, twelve or fifteen are ſufficient; after this, we wring and dry it.

When ſtuffs already coloured, are to be galled; it is neceſſary to perform it in the cold, in order that we may not alter the colours. I have found that cotton which has been alumed acquired a more conſiderable weight in galling, than that which has not been alumed; although only a ſmall quantity of the alumine is fixed upon the cotton, it communicates to it the property of combing in a greater proportion with the aſtringent principle, and even with the colouring particles.

ARTICLE V.

Of Flax.

As flax and hemp exhibit the ſame properties with regard to dying, we have ſeldom judged it neceſſary to diſtinguiſh them in this work.

If cotton is an important object of induſtry, flax and hemp deſerve particular attention both as a national production, and as the moſt extenſive ſource of labour for the poor. It is a manufacture which is to be found in every part of the country, which admits of ſubdiviſion from the fabrication of cordage to that of cambrics, which collects rural families together in the intervals from other labours, and affords them in ſome meaſure the ſweets of ſociety, which preſents an opportunity of habituating infancy to labour, and of acquiring ſomething to render old age comfortable.

At a time when we are everywhere employed in draining marſhes, and when the number of ſmall poſſeſſions muſt every day increaſe, it is a circumſtance meriting attention, that the ſoil fitteſt for the culture of hemp is that of marſhes from which the waters have been drained, and that this production is peculiarly adapted for the employment of ſmall cultivators *.

Flax ought to undergo ſeveral preparations before it is fit to receive the dye. The firſt is ſteeping; by this the bark, which is afterwards to ſerve for ſpinning, is diſpoſed to ſeparate. The ſteeping is an operation of ſo great importance, both with regard to its influence upon the quantity and quality of the product, and the deleterious qualities it may communicate to the air, that it may not be improper to give an idea of the principles on which it may be conducted.

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* Inſtruction familiere ſur la culture & le toui du chanvre a l'uſage des gens de la campagne; par M. de Pertuis.

It appears that, in ſteeping, a glutinous liquor that holds the green colouring part of the plant in ſolution, and which unites the cortical with the ligneous part, undergoes a degree of putrefaction greater or leſs according to the method we employ; for as M. Roſier has obſerved *, carbonic acid and inflammable gas are diſengaged. This ſubſtance appears to reſemble greatly the glutinous part which is diſſolved in the juice expreſſed from green plants, which ſeparates from the colouring particles when it is made to undergo a heat approaching to boiling, which putrifies and affords ammoniac by diſtillation.

Although this ſubſtance be held in ſolution in the juice expreſſed from plants, it appears, however, that water alone cannot ſeparate it from the cortical part; but it is on this account that hemp that has been ſteeped in a rapid ſtream is deficient in flexibility and ſoftneſs.

If the ſteeping is performed in ſtagnant and corrupted water, the hemp acquires a brown colour; but be-

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* Eſſai ſuo la culture & le rouiſſage du chanvre; par M, l'Abbé Roſier.

ſides this, it loſes its ſolidity, and exhales vapours which produce fatal diſorders.

It appears then, that the ſteeping is moſt advantageouſly performed in pools planted at the ſides of rivers, ſo that the water may be eaſily renewed to prevent the putrefaction from being hurtful to the hemp or injurious to health, and yet not ſufficient to prevent the degree neceſſary to render the gelatinous ſubſtance ſoluble in water.

M. Roſier found that the ſteeping would be performed when the hemp is covered with a layer of earth, and he adviſes that method ; M. Prozet * has propoſed to diſſolve a ſmall quantity of cauſtic alkali in the water in which it is performed, to increaſe its ſolvent power and prevent putrefaction ; but it appears from the experiments of Dr Home that the alkali retards the operation of ſteeping and renders the flax brittle †.

While flax is ſteeping and during the drying which ought to precede and follow it, the green colouring particles undergo a change ſimilar to that obſerved in the green ſubſtance of plants which are expoſed to the action of the air and of light ; the colour changes to a yellow, to a fawn, and even to a brown, in conſequence of the combuſtion which I explained in the firſt ſection. A great part is then ſoluble in alkalies without requiring to be any further oxigenated ; ſo that by *treating* it with an alkaline ſolution we can ſeparate from it a conſiderable portion of its colouring particles, which remain perhaps combined with a part of the gluten. It is upon the ſolution of theſe colouring particles that the proceſs publiſhed by the prince of St Sever for obtaining fine lint from hemp is founded. He orders the hemp to be lixiviated with a ſolution of two parts of ſoda to one of lime, afterwards to impregnate it with ſoap to keep it in digeſtion to waſh it well, and afterwards to comb it.

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* Mém. ſur le rouiſſage du chanvre.

† Eſſai ſur le blanchiment des toiles, p. 270.

I have attempted to bleach lint thoroughly by the method I employ for thread; but although its fibres ſhould loſe very little of their ſolidity by this proceſs, they acquire however a greater diſpoſition to ſeparate, and they become more difficult to ſpin, and form a thread much leſs ſolid.

I have made a number of comparative experiments upon lint, prepared by a method ſimilar to that of the Prince de S. Sever, and lint of the ſame kind treated in the common manner. The firſt method, afforded a greater proportion of tow, and the thread obtained by it was not finer than by the ſecond, after the latter had been lixiviated; but the former was leſs ſolid: however, there is an advantage which deſerves attention, that in the dreſſing, the lint treated in the former method was free of that powder which is ſo dangerous to the workmen.

The beauty that we produce in lint, by the preliminary lixiviations, does not ſeem to poſſeſs the advantages that its beautiful appearance gives us reaſon to expect, ſince we only diſſolve that portion of the colouring ſubſtance which would be carried away by the firſt lixiviations with which we begin the bleaching. The great degree of fineneſs we give it, is probably obtained at the expence of the length and ſolidity of its filaments.

A clergyman of the department of the Somme has rendered his miniſtry reſpectable by employing himſelf with an object in which the real proſperity of the people is ſo much intereſted. M. Brale has eſtabliſhed near Amiens a kind of public ſchool, where he examines and endeavours to diſcover the beſt method for the culture of hemp, for ſteeping it and for preparing the lint. His proceſs is not attended with the inconvenience I met with in the lixiviation of the lint; he ſteeps the hemp as ſoon as it is taken from the earth: After ſteeping he ſeparates the bark by a particular manipulation and the dipping it in a ſolution of black ſoap; he waſhes it with great care before drying; the colouring part, which is ſoluble only in alkalies, may ſtill be diſſolved and carried away by the water aſſiſted by a little ſoap; the lint is then much whiter; it divides more readily without doing ſo too much; and we have the lixiviations which ought to precede the bleaching.

Ordinary thread and cloth that is woven contain a colouring ſubſtance which may be ſeparated by ſimple lixivations; but there is a portion of this ſubſtance that is truely combined with the vegetable fibres and which can only be ſeparated by decompoſing it by the combuſtion it undergoes in combining with oxigen, as I have explained in the third chapter of the firſt ſection. Thread loſes by the operation of bleaching from a fourth to a third part of its weight.

In order to diſpoſe thread to take on the dye it is made to undergo the operations of dreſſing, aluming, and galling, deſcribed under the article *cotton*.

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THE END.